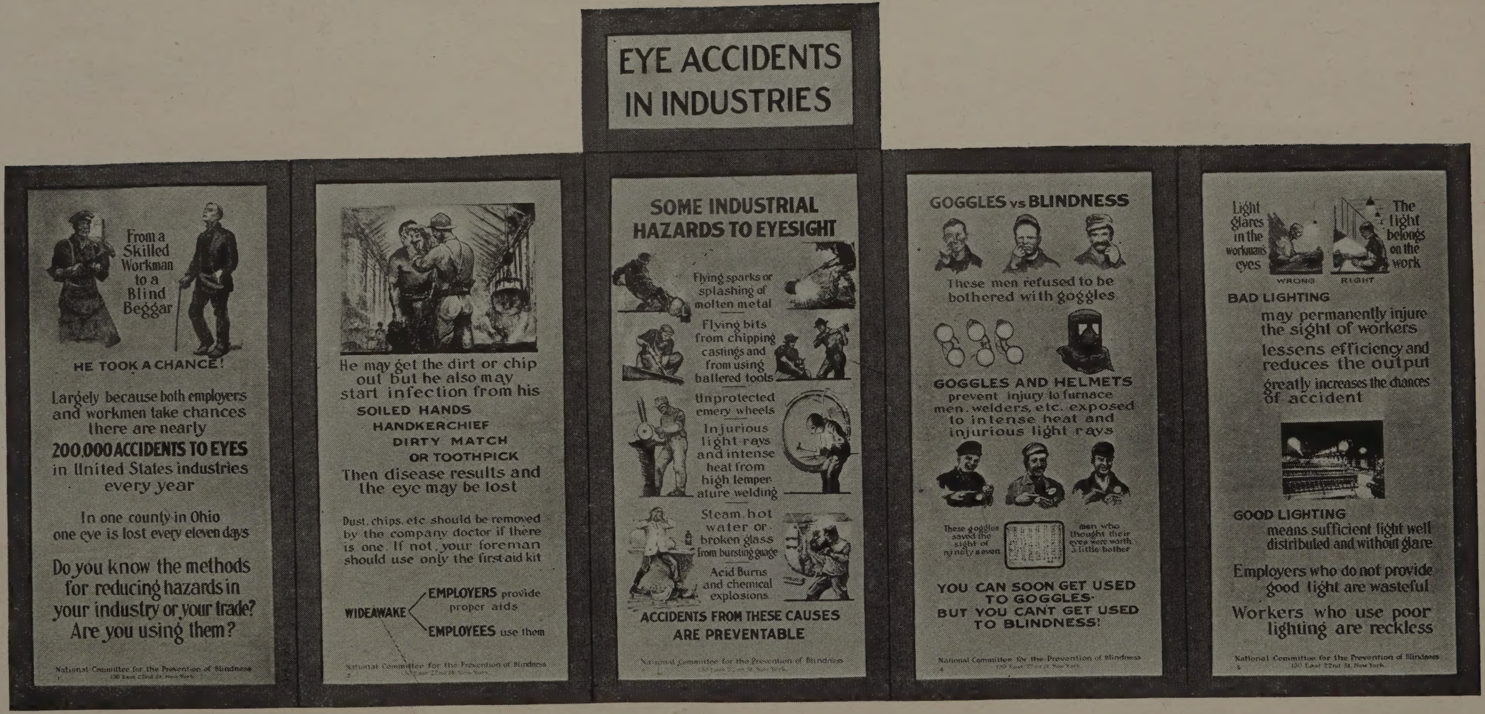

Frontispiece. A large exhibit, consisting of these five panels, measuring 34 inches by 68 inches each, may be borrowed without cost except transportation charges. (Weight, 275 pounds.) It is executed in color and makes a strong appeal. These panels have also been reproduced in black and white posters—each measuring 19 inches by 33 inches.

EYE HAZARDS IN INDUSTRIAL OCCUPATIONS

A REPORT OF TYPICAL CASES AND CONDITIONS, WITH RECOMMENDATIONS FOR SAFE PRACTICE

BY

GORDON L. BERRY, FIELD SECRETARY

NATIONAL COMMITTEE FOR THE PREVENTION OF BLINDNESS—WITH THE CO-OPERATION OF LIEUT. THOMAS P. BRADSHAW, U. S. ARMY, FORMERLY TECHNICAL ASSISTANT TO THE DIRECTOR OF THE AMERICAN MUSEUM OF SAFETY

NOVEMBER, 1917

130 EAST TWENTY-SECOND STREET
NEW YORK CITY

FOREWORD

Between August 8 and November 8, 1916, a survey of representative industries in the city of Buffalo was made by the National Committee for the Prevention of Blindness. The study was made at the invitation of a large number of leading citizens of Buffalo, the object being to ascertain the local working conditions and the industrial accident hazards which might be productive of eye injuries. The present publication has grown out of this survey.

Starting with the Buffalo study as a basis, endeavor has been made to cover also practically the entire field of hazards to the eyes in industrial occupations in the United States, with the hope that the suggestions contained herein may be welcomed in industrial concerns generally.

The usefulness and timeliness of this pamphlet are accentuated because of the abnormal demand for labor due to war-time conditions, with the consequent independent attitude of the worker, which has had a marked influence on safety work. Therefore the educational efforts of the different plants for the elimination or reduction of accidents have received the most severe test, for in normal times a worker may observe shop rules and regulations largely in order to insure his employment.

Where the working force has been greatly increased, we may expect the new employes to be subject to more injuries than under normal conditions. The rushed work and the large number of new employes unacquainted with the plant conditions, together with the impossibility of foremen giving to each the proper amount of attention, are in some measure responsible for an increased toll of injury.

The large floating supply of labor can receive but little safety education, and these workers are a constant source of worry to safety engineers. Many of this class of newly employed workmen will seek employment elsewhere rather than

conform to safety rules and regulations which are not to their liking. Because this condition has obtained in many manufacturing plants, enforcement of safety rules has not always been insisted upon. Again, the necessity of seeking and developing new processes of manufacture, unknown in this country before the beginning of the war, has confronted safety workers with unfamiliar problems, with the solution of many of which they are yet engaged. It is almost needless to state that the urgency for safety effort meantime has increased to a marked degree.

SCOPE OF THE BUFFALO INQUIRY

In the city of Buffalo 70 plants, employing a total of 35,000 workers, were studied. These embraced many different types of industry. To include a large variety and to go into a careful study of all the various operations wherein hazard to eyesight may exist were the principles of selection. There were inspected plants having a small number of employes as well as those with thousands on their payroll; manufactories located under favorable and those under unfavorable conditions were included. Pains were taken to visit plants whose managers had for an extended time taken interest in safety work and where effective results had been obtained, for in them are presented fields for study in which much valuable information may be secured. Several plants were studied from the lighting standpoint alone.

LIST OF PLANTS STUDIED

Stone, Clay, Glass Products

Buffalo Glass Company	Mirrors, leaded glass, etc.
Wm. J. Crawford and Company	Monuments
Barber Asphalt Paving Company	Asphalt paving machinery
Dwelle-Kaiser Company	Beveled glass

Brass, Copper, Aluminum

George A. Ray Mfg. Company	Houseware
Sherwood Mfg. Company	Brass and copper specialties
Aluminum Castings Company	Aluminum castings
Buffalo Chemical Fire Extinguisher Co.	Fire extinguishers and fireless cookers

Gold, Silver, and Precious Stones

Heintz Brothers	Gold rings
King and Eisele Company	Rings, badges, lens grinding, jewelry

Sheet Iron Works

Republic Metalware Company	Tinware

Hardware

Buffalo Wire Works, Inc., Plants A & B	Wire goods

Castings, Forgings, Etc.

Barcalo Mfg. Company	Brass and iron bedsteads
Bicalky Fan Company	Fans and ventilating apparatus
Farrar and Trefts, Inc	Iron castings
Lake Erie Foundry Company	Castings
Buffalo Forge Company	Forges and blowers
Strong Steel Foundry Company	Steel castings
Jewell Steel and Malleable Company	Castings
Lackawanna Steel Company	Steel products

Machinery

Eastman Machine Company	Cloth-cutting machinery
Wittemann Company	Brewers' machinery
Otis Elevator Company	Elevators
Niagara Machine and Tool Works	Machines and tools
E. & B. Holmes Machinery Company	Cooperage machinery
Manzel Brothers Company	Oil and air pumps
American Radiator Company	Radiators
Buffalo Gasoline Motor Company	Gasoline motors and marine engines
John E. Smith's Sons Company	Butchers' machinery
Buffalo Foundry and Machine Company	Machinery and castings
Contractors Plant Mfg. Company	Hoisting machinery
J. W. Ruger Mfg. Co	Bakers' machinery
Sterling Engine Company	Gas engines
King Sewing Machine Company	Sewing machines

Instruments and Electric Apparatus

Ericsson Mfg. Company	Telephones, magnetos, etc.
United States Headlight Company	Headlights
Buffalo Scale Company	Scales

Carriages and Automobiles

Pierce-Arrow Motor Car Company	Automobiles
Ford Motor Company	Automobile assembly
Atterbury Motor Car Company	Automobiles

Car and Railway Repair Shops

International Railway Company	Car repairing
Pennsylvania Railroad Company	Car repairing
American Car and Foundry Company (Depew and Niagara plants)	Freight cars
New York Central and H. R. Railway Company	Locomotive repairing

Paper and Paper Goods

F. N. Burt Company, Ltd., Plants A, B, C.	Paper boxes

Pianos, Organs, and Other Musical Instruments

C. Kurtzman and Company	Pianos

Boots and Shoes

Niagara Shoe Company	Children's shoes
John Ebberts Shoe Company	Women's shoes

Miscellaneous Leather and Canvas Goods

McKinnon Dash Company	Leather dashboards and enameling
Schoellkopf and Company	Tanning sheepskins

Rubber Goods, Buttons, Brushes

Hewitt Rubber Company	Rubber goods

Chemicals, Oils, Paints, Etc.

Wood Products Company	Wood alcohol
Larkin Company	Soaps, perfumes, premiums
Contact Process Company	Acids
General Chemical Company	Chemicals and acids
Schoellkopf, Hartford and Hanna	Aniline dyes

Women's Garments and Furnishings

Wm. Hengerer Company	Altering suits, etc.
Barman Bros. Company	Dresses

Beverages

Lang-Gerhard Brewery	Beer
Magnus Beck Brewing Company	Beer

Textiles

Monarch Knitting Company, Ltd	Sweaters
Buffalo Silk Fabric Company	Silk
Gould Coupler Company	Car couplers
Gould Storage Battery Company	Storage batteries

METHOD

In the plant inspection each operation was studied, and the use and efficacy noted of such protective devices as had been provided. The attitude of employer and workman alike toward the need for eye protection in any process, or toward the use of the protective features, was made the subject of special inquiry. Not only on mechanical points and theory were the workmen sounded, but also their opinions were sought on the problems of illumination that presented themselves.

Following inspection of each plant, a conference was held with the officials in charge. Criticisms and suggestions were made for the betterment of plant conditions. It is gratifying

to be able to state that in every case this unbiased criticism was received with marked interest, and frequently the investigator was urged to advise in detail regarding safety plans and methods for early adoption.

ACKNOWLEDGMENT

Formal acknowledgment is here gratefully rendered to those who made possible this survey of industrial conditions in Buffalo, and to those who have given most generously of their time and constructive criticism in the preparation of the text of this publication.

For their assistance at different periods and for their interest in the work the Committee is especially indebted to Dr. Ellice M. Alger, New York; Mr. Edward J. Barcalo, President, Associated Manufacturers and Merchants (of New York State), Buffalo; Mr. David S. Beyer, Manager, Massachusetts Employees' Insurance Association, Boston; Dr. Nelson M. Black, Milwaukee; Mr. Raynal C. Bolling, General Solicitor, Chairman of Committee on Safety, United States Steel Corporation, New York; Mr. A. E. Brock, Secretary, Wholesale Merchants' and Manufacturers' Association, Buffalo; Mr. W. H. Cameron, General Manager, National Safety Council, Chicago; Mr. C. L. Close, Manager Bureau of Safety, Sanitation and Welfare, U. S. Steel Corporation, New York; Dr. Colman W. Cutler, New York; Mr. Mark A. Daly, General Secretary, Associated Manufacturers and Merchants (of New York State), Buffalo; Mr. Marcus A. Dow, General Safety Agent, New York Central Lines, New York; Dr. Francis E. Fronczak, Health Commissioner, Buffalo; Dr. Harold Gifford, Omaha; Dr. Franklin C. Gram, Department of Health, Buffalo; Dr. F. Park Lewis, Buffalo; Mr. Preston S. Millar, New York; Mr. George S. Rice, Bureau of Mines, Washington, and Mr. George H. Stickney, Harrison, New Jersey.

In large measure the local success of the Buffalo survey was due to the uniform courtesy of the plant officials and safety directors of the 70 organizations visited, to their readiness to assist the investigator in his study of plant conditions, and to the various contributions which they have made in models, diagrams, photographs, statistics, and general information.

There will be available a synopsis of this publication which may be used as the basis of a lecture, amplified by lantern-slide illustrations depicting every hazard and protective device mentioned herein. Copies of the lantern slides may be purchased at cost or will be loaned with the synopsis without charge other than transportation expenses upon application to the Secretary, National Committee for the Prevention of Blindness, 130 East Twenty-second Street, New York City.

EDWARD M. VAN CLEVE,
Managing Director, National Committee for the Prevention of Blindness.

New York, N. Y.
November, 1917.

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DIGEST OF AVAILABLE STATISTICS ON EYE ACCIDENTS IN U. S. INDUSTRIES

State	*Source of Information*	*Time Period Covered*	*All Accidents*	*All Eye Accidents*	*Accidents Resulting in Total Disability*	*Accidents Resulting in Total Loss of Sight*	*Accidents Resulting in Permanent Partial Disability*	*Eye Accidents Resulting in Permanent Partial Disability*	*Accidents Resulting in Temporary Disability*	*Eye Accidents Resulting in Temporary Disability*	*Remarks*
California	Report of the Industrial Accident Commission	July 1, 1915, to July 30, 1916	67,538	6,636	..	..	1,264	175	65,741	6,461	
Illinois	Third Annual Report of the Industrial Board of Illinois	Year ended June 30, 1916	16,869	542	..	..	..	55	16,744	..	
Indiana	Annual Report, Industrial Board of Indiana	Sept. 1, 1915, to Aug. 31, 1916	36,173	3,870	..	32	..	..	..	3,233	
Maine	Statement by Roscoe A. Eddy, Commissioner of Labor	July 1, 1914, to June 30, 1916	1,028	28	..	2	..	..	..	..	Figures shown herewith are computed on the basis of two years—as covered in the statement.
Maryland	Second Annual Report of the State Industrial Accident Commission	Nov. 1, 1915, to Oct. 31, 1916	31,324	2,653	..	19	304	..	..	..	
Massachusetts	Third Annual Report of the Industrial Accident Board	July 1, 1914, to June 30, 1915	94,967	6,634	25	1	938	104	94,572	6,529	
Minnesota	Fifteenth Biennial Report of the Department of Labor and Industries	Year ending June 30, 1916	5,040	149	5	1	485	69	4,473	80	
Montana	First Annual Report of the Industrial Accident Board	Year ending June 30, 1916	6,802	250	3	1	89	11	6,574	238	
New Hampshire	Eleventh Biennial Report of the New Hampshire Bureau of Labor	Year to Aug. 31, 1916	296	20	..	..	..	..	..	..	
New York	Bulletin No. 68, Department of Labor of the State of New York	Year ended Sept. 30, 1913	94,523	7,855	..	0	2,412	96	64,307	7,759	

Ohio	Bulletin of the Industrial Commission of Ohio, Vol. IV, No. 3	Twelve months ending June 30, 1915	73,525	8,350	..	..	1,643	255	71,400	8,095	Of the 8,095 eye accidents listed in last column, 8,000 were due to "foreign body in the eye" and the remainder represent "photophobia" (extreme sensitivity to light).
Oklahoma	First Annual Report of the State Industrial Commission	Sept. 1, 1915, to Aug. 31, 1916	9,058	885	..	24	..	..	..	..	
Oregon	Statement by William A. Marshall, of the State Industrial Accident Commission	Year ending June 30, 1916	4,479	188	..	..	..	18	..	171	
Pennsylvania	Statement by Paul N. Furman, Department of Labor and Industry	Calendar Year, 1916	251,438	20,665	..	332	..	..	..	..	
Tennessee	Fourth Annual Report, Tennessee Department of Workshop and Factory Inspection	Dec. 1, 1915, to Dec. 1, 1916	567	31	..	..	..	..	..	..	
Vermont	Report of the Industrial Accident Board	Year ending June 30, 1916	1,808	164	..	..	..	..	..	..	
Washington	Fifth Annual Report of the Industrial Insurance Department	Year ended Sept. 30, 1916	15,136	516	17	5	1,381	100	13,459	416	
Totals	...	...	710,571	59,436	50	417	8,516	883	337,270	32,982	--

THE FOLLOWING STATISTICS, THOUGH TOO INCOMPLETE TO INCLUDE FOR COMPARATIVE DATA, ARE NEVERTHELESS INTERESTING AND INDICATIVE

Michigan	Statistical Report of the Industrial Accident Board	1916	19,063	..	1	0	1,713	91	16,961	..	
West Virginia	Report of the State Oompensation Commissioner to June, 1916	July 1, 1915, to June 30, 1916	20,101	..	18	9	261	71	18,860	..	
Wisconsin	Fifth Annual Report, Workmen's Compensation Industrial Commission	July 1, 1915, to June 30, 1916	12,848	..	194	41	732	34	11,978	..	About 3 per cent. of the industrial accidents occurring in Wisconsin are eye accidents.
Wyoming	First Report of the Workmen's Compensation Department of the State of Wyoming	Eighteen months ending Sept. 30, 1916	614	..	3	..	50	7	535	18	Note that figures given are for an eighteen months' period, rather than for one year.

NOTE: Blank spaces in the foregoing table indicate failure to secure data, and should not be considered as indicating no disabilities under the respective headings.

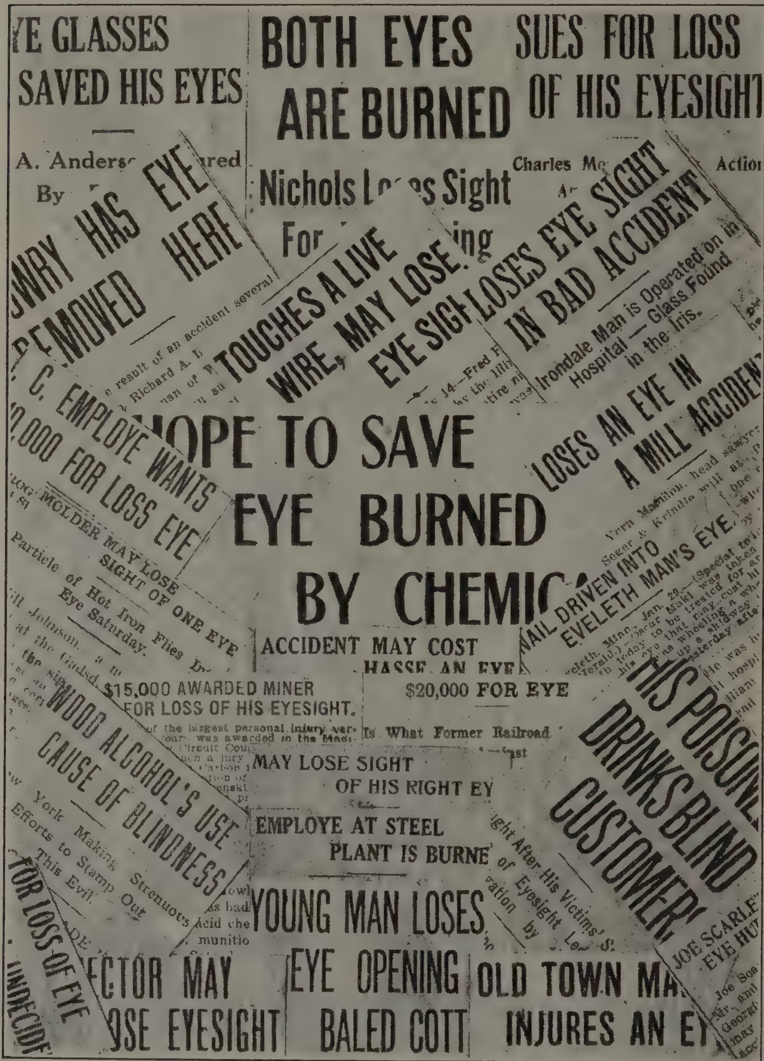

Fig. 1.—"All in the day's work."

EYE HAZARDS IN INDUSTRIAL OCCUPATIONS

Classified facts respecting the hazards in industrial occupations have from time to time been collected by various investigators. Probably the most reliable compilation of these figures is that made by the Prudential Life Insurance Company of America, under the direction of Mr. Frederick L. Hoffman. Mr. Hoffman's investigations show that during the year 1913 there were approximately 25,000 fatal accidents, 300,000 serious injuries, and 2,000,000 other injuries to workmen in the United States. For the year 1916 he predicts that there will probably be shown, when all figures are in, a reduction of about 12.3 per cent. in fatal industrial accident frequency, and a reduction of about 28 per cent. in serious industrial accident frequency. If the statistics, when in, bear out that premise, the figures will be: about 22,000 deaths from industrial accidents, and about 500,000 accidents sufficiently serious to lay the workman off for a period of more than four weeks.

Until within a very recent period no special effort has been made to ascertain what general percentage of this tremendous number of industrial accidents is that in which the eyes are concerned. The lack of such information has doubtless been due to the fact that but a very few organizations would be sufficiently concerned with such specialized data as to make the necessary study, and, secondly, because in the industrial accident reports available for such investigation there is no uniform segregated statistical information of this nature, and it is therefore necessary to study hundreds of pages of largely irrelevant material to secure such data as are available on eye injuries as separated from those affecting other portions of the body.

In the digest of the statistical investigation of this subject which has been made for inclusion in this publication (see pages 12–13), there is clear indication of the lack of uniformity in classifications of the nature of injuries recorded in annual reports

of State Departments of Labor, State Industrial Accident Boards, or State Insurance Commissions. Fortunately, however, there appears to be a growing disposition to adopt the uniform methods of reporting and preparation of statistical information, as recommended by the United States Bureau of Labor Statistics, so that it is to be hoped that within a few years complete information along this line will be available.

The following states provide reports from which it has been possible to ascertain the total number of industrial accidents and the number of these which have been eye accidents during any recent fiscal year: California, Illinois, Indiana, Maine, Maryland, Massachusetts, Minnesota, Montana, New Hampshire, New York, Ohio, Oklahoma, Oregon, Pennsylvania, Tennessee, Vermont, and Washington.

The reports do not coincide so far as dates are concerned. They give, however, the statistics for the latest twelve months' period on which data are available, and show that for the latest respective fiscal years reported on to June, 1917, there are recorded 710,571 industrial accidents. Of this total there have been reported 59,436 eye accidents, thus establishing approximately 8.3 per cent. for eye accidents, in a total of one-third of all non-fatal accidents occurring annually in the United States.

In any consideration of the statistics on industrial accidents it must be borne in mind that for one exemption reason or another there are thousands of employers and employes in the various states not covered by the State Acts. Many of the annual reports include statements similar to the following:

"Quite difficult to get the proprietors of the smaller establishments to report promptly; railways operating in interstate commerce are exempt."—*Vermont.*

"Act applies to construction of railways within the State, but not to the operation of same."—*Washington.*

"Only accidents causing a seven-day loss of time are reportable. Without doubt many accidents are not reported."—*Tennessee.*

"Not applicable to business or employments operating in interstate commerce."—*Wyoming.*

"Bill requiring all employers to report industrial accidents failed of passage in the 1915 legislature. Statistics secured are

from employers now working under the compensation provisions of Chapter 163, Laws of 1911."—*New Hampshire.*

"But only about two-thirds of the injuries occurring in this state are protected by insurance companies privately owned, or by the State Fund. Again, two of the largest groups of employers are engaged in interstate commerce and agriculture, and are exempted from the compensation provisions of the Act. Only 66.34 per cent. of the injured are covered by private or state insurance. Only 84.5 per cent. of the industrial injuries in California are covered by the Act."—*California.*

"Railroad or farm accidents are not included, or accidents in shops where less than four persons are employed."—*Wisconsin.*

"A large number of employers still not under the Act."—*Maryland.*

"Only 5700 out of 31,000 persons operating under the Act are reporting accidents."—*Illinois.*

"Casual laborers, farm and railway employes excluded. Act is elective—many employers are privately insured."—*Minnesota.*

These few quotations are typical of exemptions which obtain in other states as well. They are cited merely as evidence of the conservative nature of the estimate made by the National Committee for the Prevention of Blindness that 200,000 eye accidents in industrial occupations occur annually in the United States—that total being approximately 10 per cent. of all industrial accidents.

In Montana, Minnesota, Michigan, West Virginia, Wisconsin, Washington, and Massachusetts, accidents resulting in total loss of sight are shown to have been 58 out of a total of 263 resulting in total disability. These are the only states whose reports make possible a comparison of such data.

In California, Montana, Minnesota, Michigan, Ohio, Wisconsin, West Virginia, Washington, New York, and Massachusetts, eye accidents resulting in permanent partial disability are shown to have been 1006 out of a total of 10,918 accidents of all kinds which caused permanent partial disability. On this basis the percentage under this classification would be 9.2 per cent. for eye accidents.

In California, Montana, Minnesota, Ohio, Washington, New York, and Massachusetts, eye accidents which have produced but temporary disability are shown to number 29,578 out of a total of 320,526 accidents under the same classification—a little more than 9 per cent.

It has not been possible to ascertain the total annual award in compensation payments to those who have been the victims of industrial eye accidents. Nor can the loss of time from the injury sustained be determined. The records of individual corporations cannot be used for determination of the desired statistics, because of the varying hazards, exposures, protection afforded, or other contributory issues which would fail to coincide in any such general compilation.

In this connection the attention of the reader is called to interesting and informative statements on the subject, contained in a recent government publication, "The Blind Population of the United States." This document is based on the census of 1910.

Many statements relative to the causes of blindness are made in that publication, with some comparative data regarding industrial accidents and blindness resulting therefrom. For instance, the 1910 figures show six times as many blind persons as were reported in 1850, whereas the general population was scarcely quadrupled during the intervening period. Each decade with the exception of the last shows an increase in industrial eye accidents and occupational eye diseases. Again, it appears that 59 per cent. of the blind population is located in the New England, Middle Atlantic, and North Central States. These same states, it must be admitted, hold 55 per cent. of our total population, but they are the centers of a *much higher percentage of our industrial activities.*

Furthermore, at each census in recent decades the number of blind males has been considerably in excess of the number of blind females—nearly 30 per cent. greater in 1910. This marked difference cannot be attributed to a great preponderance of men in the general population, as there are but 106 males to every 100 females. Rather is it explained by the fact that "certain important causes of blindness, particularly injuries in mine ex-

plosions and other industrial accidents, are causes affecting the male population almost exclusively."

The period between 1880 and 1900 was one of great industrial growth in this country. It is significant that there was also a 25 per cent. increase in blindness during those years.

On page 98 of "The Blind in the United States" (the *complete* Census report on the blind) is the following statement: "The most important fact brought out by the table is the large number of cases in which blindness is caused by injuries in accidents or otherwise. Of the total number of blind persons who returned special schedules, 13.5 per cent., or more than one-eighth, reported their blindness as due primarily to this cause, these including all who lost one eye through injury and the other through sympathetic inflammation. As the conditions preventing an accurate return of the cause of blindness would presumably not apply to cases where the blindness was due to accidental causes, the figures just given in all probability afford a reasonably accurate indication of the relative number of cases in which blindness resulted from injury, although, as the enumerated blind population not returning schedules was made up largely of persons among whom, by reason of sex, age, or race, the number of cases of accidental blindness was likely to be below average, it is possible that the percentage given above may to some extent overstate the facts."

As to the incidence of eye accidents, the cases of blindness resulting therefrom, and their economic significance, it would seem, from a review of available reports, that the following statements, the absolute accuracy of which cannot of course be determined, are probably approximately correct:

1. Of the 2,000,000 annual non-fatal accidents, probably 200,000 are accidents to the eyes.
2. Approximately 15,000 persons in the United States are blind today as the result of accidental injury in industrial occupations.
3. The maintenance of these blinded artisans during the remainder of their lives will cost nearly ten million dollars, which expense will fall in large part on relatives, community, or state.

4. The actual economic loss cannot be estimated, and the loss to the unfortunate person whose eyesight is destroyed is, least of all, a matter of dollars and cents.

From these statements is it not apparent that one of the most important industrial problems of today is that of the protection of employes from accidents that will destroy or greatly impair vision?

The various hazards to the eyesight of industrial workers are found chiefly in the following industries and occupations: the manufacture of iron and steel; machine operations; chipping; grinding and polishing; riveting; welding and cutting; mining and quarrying; occupations in which there is exposure to irritating and poisonous dusts, fumes, and gases; the chemical industries and occupations involving the handling of acids and chemicals; metallurgic operations where there is great exposure to intense light and heat; glass-making; sand-blasting; woodworking operations; the garment trades and agricultural pursuits. These are not cited in the order of their importance as productive of eye accidents, neither does the above list include all the hazardous occupations to be described herewith. Statistics which would permit of other than an approximate statement as to the relative importance of these hazards are not available. It will doubtless come as a surprise to some to note the exceedingly large number of eye accidents cited in the section devoted to agricultural occupations (p. 106). A prominent oculist who has made an especial investigation of accidents of this nature, and who has seen thousands of cases for which some agricultural employment was directly responsible, states as his belief that this occupation should head the list of causes responsible for eye accidents.

On the following pages descriptions are given of the dangers in these various occupations, with recommendations for the installation of protective devices or for such changes in working conditions, lighting arrangements, etc., as will prove effective in reducing or completely eliminating the preventable industrial accidents to eyes.

CHIPPING OPERATIONS

Case: Anthony Panfield, a wheel-shop employe at Brooks Works, bought a pair of goggles at a ten-cent store because they were lighter than the ones furnished by the company. While chipping with an air hammer a small chip broke a lens and small pieces of glass struck his eye. A larger chip would have destroyed his eye. He did not know that the frames of goggles must be rigid to retain the broken glass. He knows now. Let us furnish you your goggles. They cost you nothing.—*Accident Bulletin No. 201 of the American Locomotive Company.*

In the case cited above appear two of the chief hazards to eyesight in industrial life. The *kind* of work in which the employe was engaged provides the first. His *carelessness* in using *poor protection* for his eyes is the second. This latter problem will be discussed in a subsequent section.

Fig. 2.—Protective goggles for chippers, showing side screens and frontal guard.

The possibility, or rather probability, of eye injuries occurring from flying chips, when protective goggles are not worn by the chippers, is well known. The dangers incident to the penetration of the eyeball by a fine sliver of steel, or especially of

brass or copper, are serious, and such accidents have often progressed to infection and loss of sight. These flying chips attain an almost unbelievable velocity, and have been known to penetrate the eyeball so deeply as to lodge in the optic nerve. Oculists frequently are called upon to remove chips which have lodged in the posterior part of the eye.

In the steel industry a chipping operation frequently responsible for injuries of this nature is the removal of surface cracks or seams from the cold steel blooms. A bloom is a roughly prepared mass of iron intended to be drawn out under the hammer or between the rolls into bars. In this work groups of employes frequently work toward one another from opposite ends of the bloom. In one plant in Buffalo the investigator noted more than a hundred men thus working together, all using air-hammer chisels. A constant fusillade of steel chips was the natural result. Every man in that particular group of one hundred was wearing suitable goggles which had been provided by the company. Men who work at the rolls of a blooming mill are constantly exposed to injury from flying scale, and should be protected by a mask made of fine wire netting.

Recommendations: The use of goggles is the most effective means of preventing eye accidents from this cause. Inasmuch as this type of work has proved so exceedingly productive of eye injuries, and because it is frequently turned over to ignorant, unskilled labor, it is essential that educational work and constant supervision of chipping gangs by foremen should supplement the provision of goggles.

Goggles provided for chippers usually have side screens, as shown in Fig. 2, for the deflection of chips coming from a lateral direction, as they will, especially when chippers are working side by side or in groups. The tendency has been noted among some safety directors to eliminate these side-pieces.

As they contribute to the steaming of goggles and provide additional discomfort because of their weight and appearance, it may seem advisable to some to center safety effort toward the constant interposition of the standing chip-screen between adjacent workers. The elimination of the side-screen will simplify the chipper's goggle, and the use of the standing screen will offset

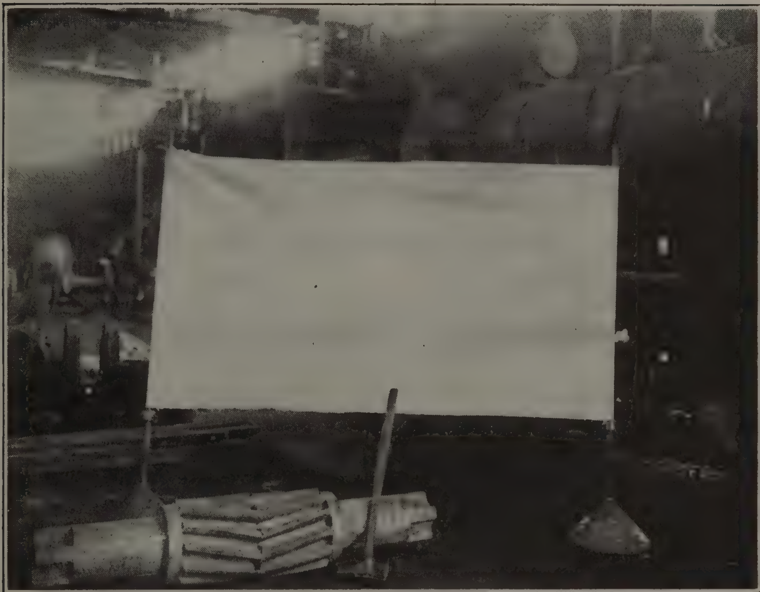

Fig. 3.—Chipping screen. American Museum of Safety.

Fig. 4.—Chippers—all wearing goggles. New Jersey Zinc Company.

the danger from chips which may be flying from a lateral direction.

The screen guard between the lenses over the bridge of the nose is advisable, and goggles should fit to the face as snugly as possible in order to reduce the possibility of chips flying up under the glass and thus causing an abrasion or penetrating wound.

Fig. 3 shows an approved type of screen in use to offset dangers from chipping. It is adjustable, made of canvas, burlap, or wire gauze, and is potent in safeguarding adjacent workers. Even greater protection should be afforded for eye hazards incident to chipping than for other occupations, because, unlike the steady, one-direction stream of particles resulting from an occupation such as emery grinding, the flying particles of metal driven off in chipping do not necessarily stream out in any one direction. Perhaps because of their cognizance of this fact chippers seem to be more ready to take chances. In the Buffalo survey it was found that chipping screens were used in but very few shops, even where safety work along other lines had advanced to a high degree of efficiency. That the screens which were in use were "doing their bit" was evidenced by the infinite number of sharp chips found clinging to the burlap.

In certain shops it was found that the soft metal chips were first broken off with a hammer, instead of their removal being delayed until they could be cut off entirely with the chisel. By this procedure there was avoided the hazard from the tremendous velocity given the chips when the operation is done with the air-hammer chisel. Moreover, such remnants as had to be removed by that process were much smaller than the original chip.

MACHINE OPERATIONS

Case: Harry Collins, of Detroit, Michigan, wore the goggles shown in Fig. 5. He is a screw-machine operator and was working on a malleable casting when the accident took place. His obedience to the rule of the shop saved his sight. —*Hudson Motor Car Company.*

Operations involving the cutting or turning of metal on machines, produce flying chips, which are a source of many eye injuries. In the turning of brass at high speeds, steel shafting

and axles, and in machining cast iron, this danger must always be taken into account. In the machining of rough castings there is also the hazard from flying sand which has adhered to the metal. This oftentimes proves as great a menace as the flying chips.

Little protection was evident in most of the machine shops visited in Buffalo. In some instances workmen were found to have taken matters into their own hands. In a number of shops they had rigged up a protective chip screen made of thin sheet metal which was fastened to the tool rest by a piece of wire. These amateurish devices frequently are the cause of accidents of various kinds. One employe who had used such a "shield"

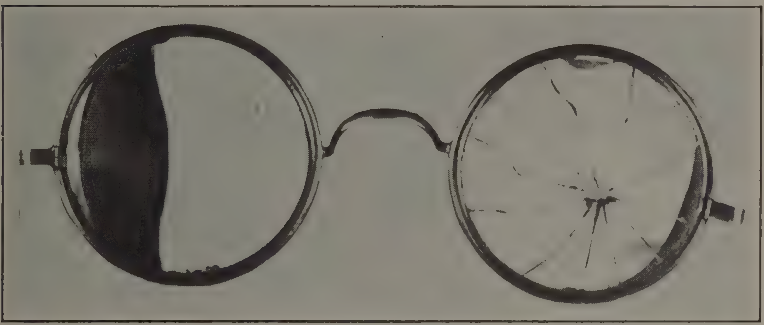

Fig. 5.—Goggles which saved the sight of a screw-machine operator.

told of how it had caught in the work on the machine, and after revolving a few times at high speed, flew off, and inflicted a severe cut on his hand.

Fine-mesh wire screens were in use by some workmen who were turning brass, an operation which produces a constant run of small brass particles. These screens had been made of wire window screen and were but loosely fastened to the tool rest.

In one small shop run in conjunction with a large foundry it was noticed that a piece of *cardboard* about eight inches square had been placed over the tool of an engine lathe, a small hole having been made in the cardboard to accommodate the tool. On further examination it was found that only a few moments

before the operator had sustained an injury which resulted in a bad bruise where a large chip had struck him in the face, half an inch below the eye. The cardboard shield expressed his desire for protection.

Recommendations: Attach a protective guard, properly designed, made of good material, and carefully fitted to the tool rest. Crude screens made and put in place by the workmen themselves will produce, rather than reduce, accidents.

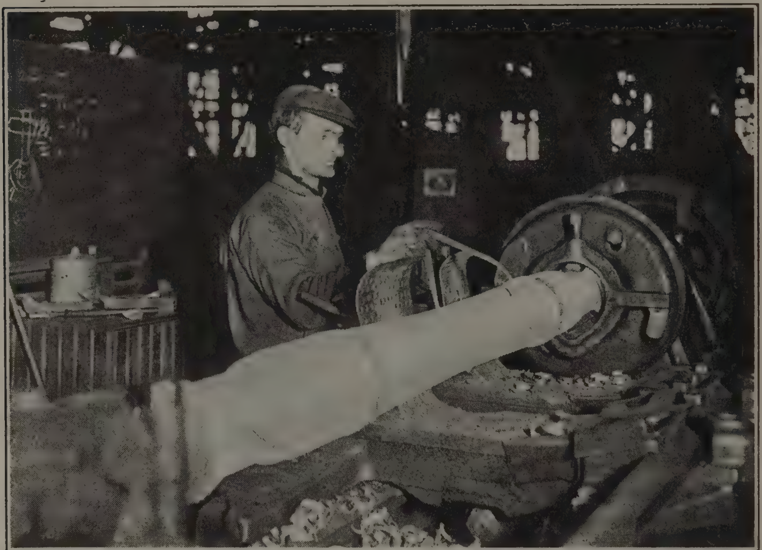

Fig. 6.—Guards on lathe to catch steel chips from tool. Carnegie Steel Company.

The guard illustrated in Fig. 6 is securely fastened to the machine and performs its function without endangering the operator.

Another type of guard frequently used is shown in Fig. 7. The guard is of glass and permits ample view of the tool and work. It can be thrown out of position when fitting up work in the machine.

ABRASIVE WHEELS

The statistics compiled by casualty companies in the United States indicate that in recent years there has been a large increase in the number of accidents resulting from the operation of emery wheels, grindstones, and the like. The increase is un-

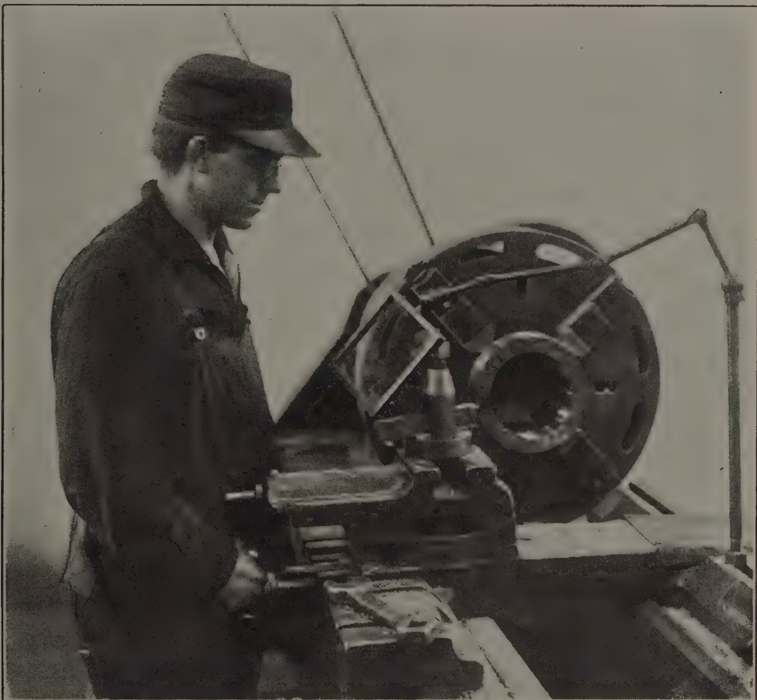

Fig. 7.—Glass chip-shield on lathe. Shield is supported by a universal jointed arm secured to tool carriage, so that it can be readily adjusted. United States Steel Corporation.

doubtedly due—(1) To the larger use of these abrasives; (2) to the failure of many industrialists to provide therefor the proper protective devices; and (3) to the failure of employes to use such devices when grinding wheels have been equipped with them.

There are few factories or other workplaces which are not equipped with one or more grinding wheels, used for rough dress-

ing, the finishing of machine parts, polishing, buffing, and the like. Emery wheels and grindstones are the ones most commonly in use. The word "emery" in this connection is frequently more or less of a misnomer, as many of the abrasive wheels classified under that name are not made of emery, but of such artificial products as alundum, carborundum, or crystolon. They are, however, commonly called emery wheels.

The hazards incident to emery grinding are those due (1) to emery dust, (2) fine particles from the metallic surface which is being ground down, and (3) flying parts of a broken wheel which has ruptured because of an accidental blow, the fouling of work between the tool rest and the wheel, improper mounting, overspeed, or excessive pressure against the wheel.

Accidents from these causes are rarely unavoidable, and the application of substantial guards, hoods, and exhaust systems to emery wheels and grindstones, with the wearing of goggles by the grinders, will reduce to a minimum accidents of this nature.

Recommendations: Safety hoods are essential to the proper equipment of emery wheels. The hood should be substantially built, and of such design and strength as to retain the parts of a wheel which ruptures. The wheel should be entirely contained in the hood, except for such portion as the nature of the work requires to be exposed.

If for any reason it is impractical to equip the wheel with a hood, safety flanges should be used. These bind the wheel on either side, and are adapted for either straight or tapered wheels. In the event of a rupture of the wheel, the parts are clamped by the flanges. The entire surface, however, is not covered by the flanges, and for this reason the protection afforded is not so complete as that given by a hood. The use of both flanges and hood will give the maximum protection. Correct dimensions for flanges to be used on different sizes and styles of wheels are cited in the following tables, approved by the National Machine Tool Builders' Association and manufacturers of abrasive wheels.

The matter of dust removal should be given careful attention, as constant breathing of air laden with emery dust is injurious, and there is a cumulative hazard to eyesight from the constant scarring of the cornea by these fine particles. An ex-

haust system, carefully planned by an expert in that line, and approaching the dust source as closely as possible, should be installed wherever any considerable amount of grinding is done.

DIMENSIONS OF TAPERED FLANGES AND TAPERED WHEELS WHERE HOODS ARE NOT USED IN CONJUNCTION THEREWITH

A—Maximum flat spot at center of flange.
B—Flat spot at center of flange.
C—Minimum diameter of flange.
D—Minimum thickness of flange at bore.
E—Minimum diameter of recess in taper flanges.
F—Minimum thickness of each flange for single taper at bore.

Diameter of Wheel in Inches	*A*	*B*	*C*	*D*	*E*	*F*
6	0	1	3	3/8	2	3/8
8	0	1	5	3/8	3½	3/8
10	0	2	6	½	4	½
12	4	4½	6	5/8	4	5/8
14	4	4½	8	5/8	5½	¾
16	4	6	10	5/8	7	7/8
18	4	6	12	¾	8	1
20	4	6	14	¾	9	1
22	4	6	16	¾	10½	1 1/8
24	4	6	18	¾	12	1 1/8
26	4	6	20	¾	13½	1 1/8
28	4	6	22	7/8	14½	1¼
30	4	6	24	7/8	16	1¼

STRAIGHT FLANGES AND STRAIGHT WHEELS USED WITH PROTECTION HOODS

A	*B*	*C*	*D*
Diameter of Wheel in Inches	*Minimum Outside Diameter of Flange*	*Minimum Diameter of Recess*	*Minimum Thickness of Flange at Bore*
6	2	1	3/8
8	3	2	3/8
10	3½	2¼	3/8
12	4	2¾	½
14	4½	3	½
16	5½	3½	½
18	6	4	5/8
20	7	4½	5/8
22	7½	5	5/8
24	8	5½	5/8
26	8½	6	5/8
28	10	7	¾
30	10	7	¾

Wheels shall never be run without flanges.

Both flanges in contact with the wheels shall be of the same diameter, whether straight or tapered.

In connection with the problem of safeguarding grinding wheels the following statement from one of the largest manufacturers of safety guards is of interest:

"While the chances of eye injuries are not quite so great when a grinding wheel is protected by means of a suitable guard, nevertheless goggles should always be worn by grinding machine operators, with the possible exception of certain kinds of wet precision grinding, for example, automobile crankshafts. When these are being ground, the point of contact between the grinding wheel and the work is always under a large stream of water, which has sufficient mass and velocity to carry down into the tank of the grinder any particles which otherwise might cause eye injuries."

Goggles for work of this nature need be neither heavy nor cumbersome. The thickness of the lens should be based on the kind of grinding in which the workman is engaged. The lightweight type should not be used except for work where fine particles are thrown off. Side screens on goggles are efficacious where protection is necessary to offset the danger of chips from grinding at adjacent machines.

A light, convenient carrying case for the goggles should be provided—in fact, everything done which will prevent any employe's leaving his goggles in his locker or which will give him any excuse for not using them. As soon as the glass has become seriously pitted from the flying emery particles, new glass should be inserted, so that the worker's vision may not be interfered with. These pitted glasses—sometimes so scarred that they look like ground glass—are an excellent indication of what might be the result upon the delicate surface of the eyes were not the protective goggles in continual use.

As has been frequently stated by oculists in discussing the results of this hazard, flying emery particles are white hot, so that when they strike the eyeball they are likely to burn their way into the tissues, thus making their removal more difficult. Though the great heat may cauterize the edges of the wound, there results an abrasion which makes it far more easy for bacteria to enter and bring about serious infection. The illustration in

Fig. 8 indicates the temperature of the emery particles, so white-hot as to fuse them fast to the lens of the protective goggle.

In numerous plants the bad practice exists of hanging a pair of goggles beside a grinding wheel for the use of any employe who may use the wheel. The promiscuous interchange of goggles exposes workmen to communicable diseases of the eye, which are easily transferred in this way. Occasionally such a pair of goggles is known to have been last worn by a man who had "sore eyes." The factor responsible for the inflammation may not be known even to that employe himself. Any other work-

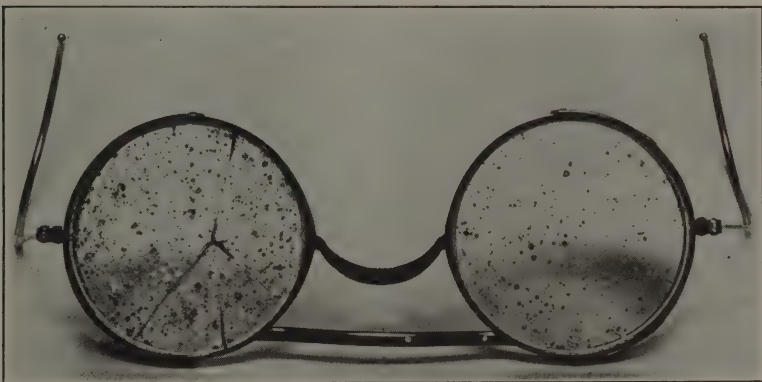

Fig. 8.—Emery particles fused to goggles.

man who wears these goggles may later develop trachoma or some other serious eye disease.

Glass guards over the tool-rest are in use to a certain extent, but in the opinion of many safety engineers they are not satisfactory, and do not make for complete safety or efficiency.

The following suggestions as to the use of emery wheels should be carefully observed. They are found in "Universal Safety Standards," compiled under the direction of the Workmen's Compensation Service Bureau of New York:

"Do not operate an emery wheel without protection for the eyes. Do not operate any emery wheel faster than the speed

recommended by the manufacturer. Be sure that the speed is right before mounting wheel."

"Be sure that the tool-rest on the emery wheel is not below the center of the wheel, and have the rest as close to the wheel as possible. Wheel should be running true and without vibrations.

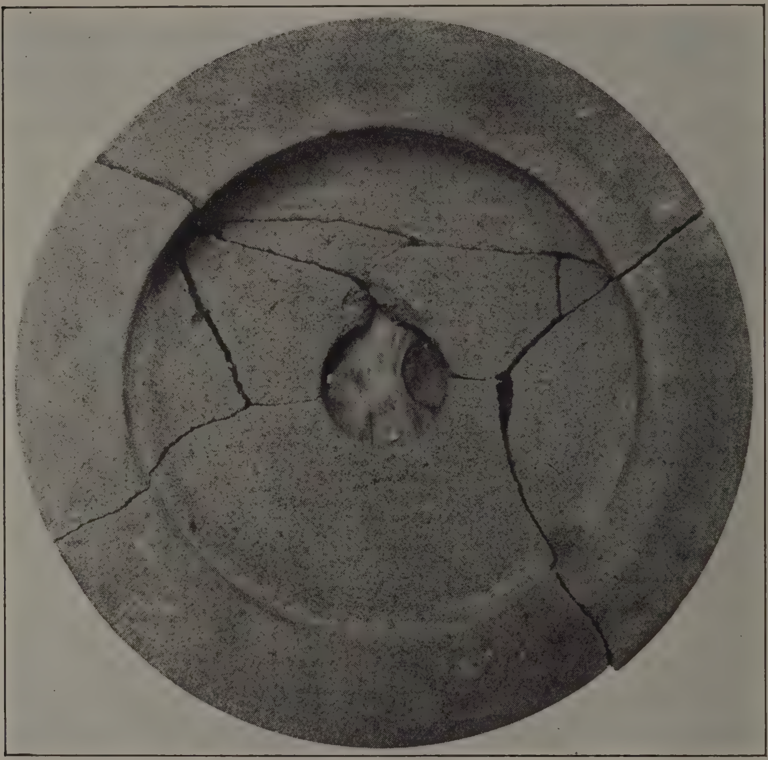

Fig. 9.—A serious or fatal accident from the breaking of this wheel was prevented by the hood which inclosed it. Oliver Mining Company.

If not, call attention of the foreman and have wheel fixed before operating."

"Always keep bearing of grinder well supplied with oil. A hot arbor may expand and break wheel."

"Be sure that your wheel is running at normal speed before starting to grind."

As regards speed, carefully compiled tables based on the diameter, composition of wheel, nature of work, and so forth, have been made available, and are usually provided by manufacturers of emery wheels. In general, a speed of 5000 peripheral feet per minute is recommended as the standard for vitrified and silicate straight wheels, tapered wheels, and shapes other than those known as cup and cylinder wheels, which are used on bench, floor, swing frame, and other machines for rough grinding. For

Fig. 10.—Motor-driven emery wheels, equipped with plate-glass shields, hoods, and exhaust system for removal of dust. United States Steel Corporation.

these latter a speed of 4500 peripheral feet per minute is recommended as standard.*

Grindstones when run at excessive speed present similar hazards as do grinding wheels. "The safe allowable peripheral speed is somewhat variable, depending upon the grade of grit and the

* Technical data on this subject, covering all phases of the safeguarding of abrasive wheels, may be found in numerous publications devoted entirely to the subject. An excellent presentation is that contained in "Grinding Wheels," Travelers Insurance Company, Hartford, Conn., and in "Safety as Applied to Grinding Wheels," The Norton Company, Worcester, Mass.

hardness of the stone. The nature of the stone is indicated by the locality in which it is quarried. The two best known and most widely used varieties are the Ohio and Huron grindstones, the latter being safe for somewhat higher speeds than the former, owing to their greater hardness and fineness of grain. Ohio stones should never be run with a rim velocity in excess of 3000 feet per minute, and should ordinarily be kept under 2500 feet per minute. Huron stones may be allowed 3500 feet per minute, but it is better to limit them to 3000 feet per minute maximum. Unknown varieties of stone should be limited to 2500 feet per minute."*

Finally, grinding machines should be so placed in relation to natural and artificial lighting as to eliminate any danger of glare. Localized lighting may sometimes, with wise installation, be employed to good advantage if adjusted so that the light source is hidden from the range of vision of the operator and other workers who may be stationed at nearby points. Even, adequate general illumination is, however, far preferable.

Frequently the most serious hazard is apparent in those shops where but occasional use of grinding wheels is required, where the emery wheel is used perhaps for but a few moments in an entire day, to touch up some dull tool or to grind off a burr from a casting. In shops where emery wheels are in constant use, naturally the severity of the hazard is appreciated far more. It is a serious mistake to disparage the risk in a small shop or in any shop where but *occasional* grinding is done.

In Buffalo industries visited it was found that wherever workers were engaged in steady grinding, with but one plant as exception, goggles were in use. Frequently a plate-glass screen or other safeguard was also attached to the grinder.

SAND-BLASTING

The necessity for sand-blasting metal castings, stone surfaces of buildings, glass surfaces, *et al.*, has developed one of the most dangerous of the dust hazards to vision, and to general health as well.

In foundries the burnt sand and scale must be removed from

* "Grinding Wheels," Travelers Insurance Company.

castings. This was originally done by hand scrubbing, steel brushes being used by the workmen engaged in the task. This process was unsatisfactory both from the standpoint of result and because of the lack of protection against dust. Better methods have gradually been developed, until now the operation of sand-blasting may be accomplished practically without menace.

For small and medium-sized castings the mechanism of the tumbling mill has been called into play and the cleaning accomplished safely and satisfactorily. But there are many castings which, because of size or other reasons, cannot be cleaned by such means. Many castings are too large to be put in tumbling mills, while the fragility and fine surfaces of others may also be the reasons for using some other process.

Sand-blasting of large areas is generally accomplished by the use of the hose type of apparatus, which permits of a stream of sand being shot with great force against the casting or other object, the stream being directed and controlled by an operator.

Men engaged in this work must be afforded protection of the eyes and face, for the sharp particles of sand are driven with such force against the surface operated upon that they rebound many feet, and the surrounding air is constantly filled with dust produced both by the driven sand and by that which is removed from the surface being cleaned.

Fig. 11 shows a protective helmet for sand-blast operators. It covers the entire head and fits down over the shoulders snugly. Because the particles of silicious sand which is used, would, in their rebounding, rapidly pit the glass surface of goggles, rendering them useless in a very short time, the eyes of the workman must be safeguarded in another way. Consequently the helmets in use for sand-blasting have "windows" made of fine wire mesh, mica, or celluloid through which the operator may watch his work. Though sand-blasters often equip themselves with home-made helmets, far more satisfactory results are secured by providing them with the commercial product securable from any one of a number of manufacturers. They may be equipped with a hose for connection to a compressed-air system, in order to provide a constant supply of fresh air. Where such equipment is used, care should be exercised lest too strong pressure of moist

air prove in itself a hazard to the health of the worker. The air should be delivered within the helmet at only a slight pressure and be as free from moisture as possible.

W. Gilman Thompson, in his publication, "Occupational Diseases: their Causation, Symptoms, Treatment, and Prevention," describes one method of protection as follows: "The operator stands in a cabinet directing the sand-blast away from

Fig. 11.—Hood used by men sand-blasting steel ore cars. Duluth, Missabe and Northern Railway.

himself toward the casting. Over his head, at an angle of 45 degrees, a strong blower fan directs a stream of air also upon the casting with such force that the dust of both sand and metal is blown downward toward the opening of a large exhaust tube just above the floor. In this way a strong, continuous draft blows the dust away from the operator and out of the cabinet through the aspirator duct, which is connected with a powerful exhaust fan."

In "Safety in the Foundry," Magnus W. Alexander gives a comprehensive description of the two general types of sand-blast rooms which may be provided for work of this nature in foundries. "The less expensive type consists of an ordinary dust-tight inclosure with a solid floor of wood, concrete, or iron. The dust is sucked out by means of a fan through openings suitably located in the outer wall or connected with a pipe which would carry the dust outside, while fresh air is drawn into the room through louvers placed in the opposite wall or in the door, or the door opening is only partially covered with a heavy canvas curtain. The sand must be shoveled up from time to time to be cleaned and reused.

"The more expensive type has grated openings in the floor through which heavy sand and scale fall, while the fine dust is drawn through the grated openings by means of a suitable exhaust; in this case the intake of fresh air is through the ceiling by means of louvers or other openings. Mechanical means remove the sand from the hoppers under the floor openings, sift it, and return it for use to the sand-blast tanks. The construction of the room is generally the same for both types. The rooms are usually lighted artificially by electric lamps placed behind heavy plate glass or wire screen to protect the lamps. Natural lighting through windows is employed only in rooms where the windows can be so located in the walls or the ceiling as to place them out of range of the sand-blast—otherwise the window-glass would be broken or would wear out quickly."

In the making of pottery and china the sand-blast is used to brush and scour the ware. The eye hazard from irritating dust in this occupation may be offset if the work is held in a box-like hood with small openings through which the workman puts his hands and arms. These cases are equipped with exhaust fans which carry off the dust. Glass windows enable the operator to watch his work, though these are likely to become pitted and opaque very rapidly unless the suction is sufficiently strong to carry off the dust-particles immediately.

"MUSHROOMED" TOOLS

Case: In the accident records of the American Locomotive Company, New York, appears the following:

"August 17th, F. Van DeBogarts, boilermaker at Schenectady, was holding a fuller which his helper was striking with hammer. Head of fuller was badly battered and a piece of scale broke off, hitting him in the eye."

In this example appears another of the chief hazards to eyesight —the danger from flying particles driven off from the burred or "mushroomed" edges of hand tools. Swages, flatters, fullers, breaking-down tools, chisels, and other tools often have their heads beaten down to a "mushroomed" condition. Tools which have been used until the heads have spread and split are a continual menace. Each blow upon such a mushroomed surface may cause chips to fly off with sufficient force to destroy an eye, or even to pass through clothing and into the flesh.

"Mushrooming" may occur on the finest hand-forged tools, as well as on those with cast heads commonly provided in cheap hammers. Less care to secure uniform results can be taken in the manufacture of the latter. They are, therefore, in all probability more hazardous, but it must be borne in mind that the hazard from mushroomed heads is not essentially due to inferior quality alone.

An injury of this nature when caused by a small particle of steel may seem of little moment at the time of occurrence. Even when the particle has perchance penetrated to the interior of the eye, its presence and effect may be at first so non-apparent that it may take considerable persuasion to make the victim realize that the accident has potentialities of a most serious nature which demand immediate and scientific attention by an oculist.

Serious infections may result due to injuries of this nature when the penetrating particle has carried with it dirt or germs into the interior of the eye, and it is of paramount importance that any injury of this kind should be considered serious and worthy of immediate attention.

The location of particles of iron and steel can often be accomplished only by means of the use of the *x*-ray. The withdrawal

Fig. 12.—"Mushroomed" tools—unsafe to use. United States Steel Corporation.

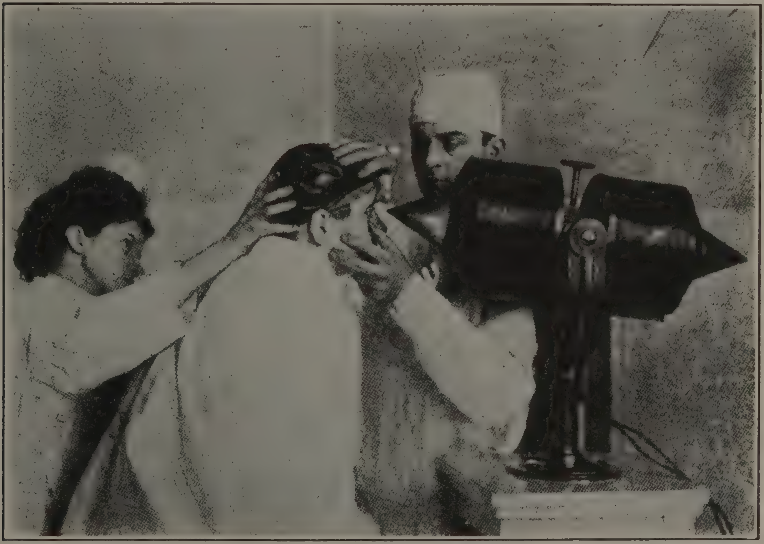

Fig. 13.—Haab magnet for withdrawing steel chips from the eye.

of a steel sliver can frequently be effected only by the use of an electric magnet. (See Fig. 13.)

Such procedure can be adopted only for such particles as are capable of being magnetized. Consequently, penetrating injuries caused by copper, brass, lead, and many alloys are much more dangerous than from iron and steel. Dr. Nelson M. Black, in his brochure entitled "The Eye in Industrial Accidents," states that in such cases it is often necessary to remove the injured eyeball in order to save the other eye, as the irritation set up is frequently transferred to the good eye, and thus, through sympathetic inflammation, leads on to blindness. The good eye may be affected at any time from a few weeks to thirty or forty years after the injury.

Recommendations: Constant watchfulness on the part of workmen and foremen is essential in order that hammering tools may be kept properly dressed. Regular weekly inspection of tools should be provided. The burred edges should then be removed by breaking down or by grinding or both. A frequent procedure is to heat the tool and then remove the burred edges by dressing.

In this connection Beyer, in "Industrial Accident Prevention," states: "The heat treatment of hammering tools is worthy of special consideration. If they are hardened slightly, the tendency to 'mushroom' is materially reduced. Care must be taken, however, to avoid getting the tool too hard, as it then becomes brittle, and pieces may break off from the head when it is apparently in perfect condition. There is a point where the tool is neither too hard nor too soft, but no definite standard of temperature can be laid down, since different grades of iron require different treatment. By practical tests an experienced blacksmith should be able to determine when the right condition is reached for the particular stock on which he is at work. For heavy hammers (those weighing 20 pounds or over) it will be advantageous to make the striking face rounded or convex. This tends to center the blow and prevent the hammer from twisting or turning in the hands of the man using it. Such twisting is liable to occur with a flat-faced hammer, if it does not strike fairly."

The recommendations of the National Safety Council (Bulletin No. 317) are excellent in their systematization of procedure for the prevention of accidents from this source, and for the elimination of chances of forgetfulness on the part of foreman or workman. They are as follows:

"1. Establish a regular tool-room for a certain number of employes.

"2. A competent workman should be placed in charge of this tool-room. His duties should consist of keeping an accurate record and seeing that all tools are dressed, ground, and properly repaired. One man should assume the responsibility of safe tools for the employes.

"3. Each tool taken from the tool-room by an employe should be recorded with a brass check—this check to contain the number of tools assigned to that employe.

"4. The employe should return tools when through with them, or account for them at least once a week. Such tools as air hammers, electric machines, etc., should be returned each evening for oiling, testing for grounds, etc."

RIVETING

Case: $20,000 for an eye. . . . An action in which he seeks to recover $20,000 for the loss of sight of his left eye was filed in the United States District Court this morning by R—— P—— of this city against the —— railroad, by whom he was employed as the operator of a triphammer. On September 28th, the plaintiff says he was engaged in removing a rivet from the truck of a railroad car and was using an automatic hammer or air gun. While so employed, he said the rivet flew out and struck his left eye, breaking his glasses and piercing his eye. He claims that the machine was defective and that he was not working in the proper light.—*Buffalo, New York, Commercial, May 17, 1916.*

In car building and other steel structural work the dangers attendant upon reaming and riveting require constant supervision of employes so engaged, and the provision of safeguards for the prevention of such accidents as might otherwise occur. In riveting especially, eye accidents must be guarded against, and in breaking down steel structures the cutting of rivet heads, bolts, et cetera, is even more hazardous.

Occasionally the valve in the air hammer sticks or breaks, and when hammer is removed from the rivet, the plunger may fly upward and strike the bucker in the face, unless he has taken the

Fig. 14.—Bucker's face should be averted when hammer man is driving upper cut rivets. Haskell and Barker Car Company.

Fig. 15.—Unsafe practice of only partially covering rivet head with dolly-bar. Haskell and Barker Car Company.

precaution to always turn his face to one side when the hammer man is driving upper cut rivets (Fig. 14).

In Fig. 15 is illustrated the danger to which a bucker exposes himself in case he covers only part of the rivet head with his dolly-bar, in the expectation that the jarring of the hammer will bring the bar completely over. The rivet head should always be entirely covered, for if it is not, the bucker stands a good chance of being shot by the rivet jumping out of the hole when the force of the hammer is applied.

Fig. 16.—Cutting rivet heads.

In cutting off rivet heads the force applied results in their flying through the air with intense velocity, and unless care is exercised, the flying head may cause serious injury to the hammer man or to some adjacent worker. Several groups of men are often found engaged in cutting rivets, working in close proximity to one another, and thus increasing the danger. Although in the case cited the victim's goggles failed to preserve his eyesight, this is but one casualty, whereas thousands of cases occur where the employes save their sight by wearing goggles.

In the railway shops and in other places in Buffalo where this

type of work was observed it was noted that most of the workmen had been equipped with goggles. Many of them, however, were not using them.

Recommendations: The provision and enforced use of strong goggles, with side screens, will usually prevent injury which might otherwise result from flying rivet heads.

A rivet-head catcher, consisting of a basket made of wire netting, on a long handle, has been used effectively in preventing accidents from this cause. As the rivet-head flies off, it is caught in the wire basket, which is handled by the cutter's helper.

RADIATIONS FROM INTENSE LIGHT AND HEAT SOURCES

Numerous inquiries have been received by the author, originating from safety engineers who are seeking information as to the effects of radiant energy upon the eye. The following paragraphs are included herewith not as any original contribution to the subject, but rather as an abstract of the most recent findings concerning possible hazards to eyesight from the radiations of intense light and heat sources.*

With the colors of the visible spectrum—red, orange, yellow, green, blue, and violet—all are familiar. These colors are produced by a mixture of vibrations or waves in the ether, which, according to their length, give us the various hues. We say that an object is red not because it actually is red, but because, when seen by daylight, it reflects or transmits only the long rays, which in the average person excite the sensation of red. If seen by light of another wave length, its color would be entirely different.

But there are other waves besides those which can thus be seen. Some of those other waves are longer than the red which borders the visible spectrum. They are designated as the "infra-

* One of the most recent and inclusive publications on the subject is that entitled "The Pathological Effect of Radiant Energy on the Eye," by F. H. Verhoeff, M.D., Pathologist and Ophthalmic Surgeon, Massachusetts Charitable Eye and Ear Infirmary, Boston, and Louis Bell, Ph.D., Consulting Engineer, and Past President, Illuminating Engineering Society. It is largely on the findings of these investigators that the following treatment of this subject is based.

red" rays and are felt as "heat." On the other side of the spectrum are likewise waves other than the visible violet. Those are the shorter ones, called the "ultra-violet" rays. It has been believed that both the infra-red rays and the ultra-violet rays could exert a very injurious action on the eye.

For comparative purposes the measurement of these wave lengths is given. The metric units will be used for this purpose, μ denoting the micron, equal to one-thousandth of a millimeter, the $\mu\mu$, equal to one-millionth of a millimeter. As will be shown, only waves within certain measurements may be harmful, hence the necessity for specifying thus fully.

Verhoeff and Bell find that "from the standpoint of effects upon the eye the ultra-violet region may be divided into two sharply separated portions, one of which produces abiotic effects while the other does not." (For general purposes the definition of the word "abiotic" contained in the quotation above is "injurious" or "harmful," as designating the effect upon living matter of the short waves of light. It must be distinguished from the "thermic" effect of light, although this, of course, may also be destructive to life.)

"It appears, therefore, that the ultra-violet rays from 305 $\mu\mu$ to 395 $\mu\mu$ are not injurious, while those from 305 $\mu\mu$ to 200 $\mu\mu$ are, and while those 305 $\mu\mu$ in length show but evanescent effects, for shorter wave lengths the injurious effects increase with considerable rapidity."

In what media, therefore, do these shorter rays exist, and to what extent are they harmful? The ultra-violet rays exist in daylight, in artificial illuminants, and in processes involving intense light and heat, such as arc welding, oxy-acetylene and oxy-hydrogen welding, furnace and other operations in which molten metals are concerned.

The possibility of injury from the ultra-violet rays in sunlight need not be discussed here, save to state that "the abiotic energy in the solar spectrum is a meager remnant between wave lengths 295 $\mu\mu$ and 305 $\mu\mu$, aggregating hardly a quarter of 1 per cent. of the total. At high altitudes and in clear air it is sufficient to produce slight abiotic effects, such as snow-blindness," which, however, occurs only with long exposures under very favorable circumstances.

ULTRA-VIOLET RAYS IN ILLUMINANTS

The experiments of Verhoeff and Bell regarding the possible injurious effect of ultra-violet rays as found in ordinary commercial illuminants cover the whole range of incandescent lamps, both gas and electric, the ordinary mercury arcs, and the ordinary Cooper Hewitt tube, flames, and arc lamps of various sorts. The wave lengths for even the highest temperature of these sources are not shorter than 300 $\mu\mu$, which length is but barely under that of 305 $\mu\mu$, at which injurious effects begin to be at all apparent. The injurious radiations furnished by even the most powerful of them are too small in amount to produce danger of photophthalmia under ordinary working conditions, even when accidentally used without their globes. The glass inclosing globes used with all practical commercial illuminants are amply sufficient to reduce any injurious radiation very far below the danger-point.

Statements which have been made to the author by leading ophthalmologists would, however, indicate that the excessive exposure to the intense light used in taking motion pictures indoors sometimes leads to photophthalmia, with intense discomfort resulting temporarily. Occasionally there appear sensational reports of cases of blindness resulting from such exposure, but so far as we have been able to ascertain, these have been greatly exaggerated, and no permanent damage has been so effected.

Artificial illuminants under any practical conditions of use expose the eye to much less severe radiation in this part of the spectrum than does ordinary daylight, and these radiations are, as indicated in the foregoing, for the most part arrested by ordinary commercial glass, such as lamp chimneys and incandescent bulbs. Ultra-violet rays are also arrested by the cornea, vitreous humor, and the lens of the human eye, and so do not reach the deeper structures at all—offsetting the possibility of permanent damage being effected.

Artificial illuminants may prove very tiresome through the sharp contractions of the pupil which they produce, and through the premature, though generally temporary, exhaustion of the retina, but, generally speaking, intense light results in fatigue and inefficiency rather than demonstrable harm.

Disturbance of color vision, persistent and annoying after-images may be expected, but Verhoeff and Bell indicate their belief most clearly in the statement "as regards definite pathological effects or permanent impairment of vision from the exposure to the luminous rays alone, we have been unable to find either clinically or experimentally anything of a positive nature.

"Experiments on animals and on the human subject as well prove that the retina may be flooded for an hour or more with light of extreme intensity (not less than 50,000 lux) without any sign of permanent injury. Only when the concentration of light involves enough heat energy to produce definite thermic lesions is the retina likely to be injured."

RADIANT ENERGY IN ARC WELDING AND IN MOLTEN METAL

The operations listed in the following table* are among the most prominent of those wherein workmen are exposed to radiation which might have a harmful effect on vision unless protection through colored goggles is afforded.

Group	*Process*	*Approximate Temperature*
Open-hearth steel . . .	Charging machine	3400° F.
	Steel pourers	2800° F.
	Platform men	3000° F.
	Melters	2800° F.
Crucible steel	Melting floor	3400° F.
	Hand pouring	2800° F.
	All steel pouring	2800° F.
Bessemer steel	Pulpit operators	3600° F.
	Blowing steel	3600° F.
	Pouring in molds	2800° F.
Blast furnace steel . .	Tapping	2800° F.
	Tuyères	3500° F.
Wrought iron	Puddling furnace	2800° F.
Furnaces	Gas heating	2500° F.
	Electric heating	5000° F.
	Large electric heating	6000° F.
Welding	Oxy-acetylene cutting	4000° F.
	Oxy-acetylene welding	4350° F.
	Light spot welding	
	Heavy spot welding	
	Iron arc welding	5500° F.
	Carbon arc welding	6450° F.
	Lap-weld	

* "Safety," Special Supplement, May, 1917.

After exposure of the eye to injurious radiations, there is a latent period before any effects become perceptible. This period in a general way varies with the severity of the exposure, but is usually apparent within twenty-four hours. Modern processes of welding, as included in the foregoing table, involve the application of intense heat concentrated for the liquefaction of the metals, which thus mix—and unite as they cool. The electric

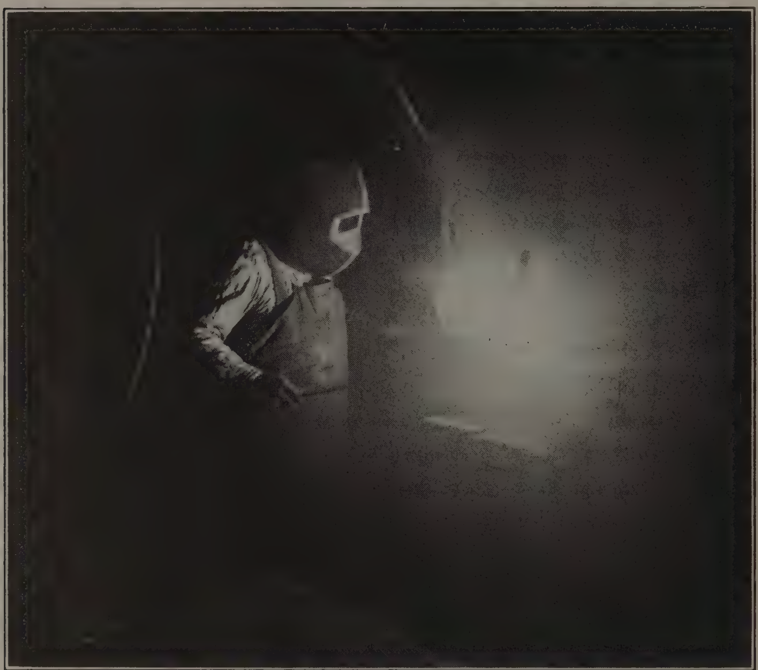

Fig. 17.—Arc welding.

arc, the oxy-acetylene torch, and the oxyhydrogen flames are welding media against the radiations of which workmen should always be protected.

Regarding *permanent* damage to the eye from the ultra-violet waves which are emitted even from these processes, it would seem that many statements which are gross exaggerations have obtained credence, whereas, so far as effecting any perma-

nent damage, these rays cannot be held responsible therefor. In fact, seldom is there anything more than a mild conjunctivitis produced which disappears in a day or two.

The infra-red rays (of long wave length) are prominent in such sources as molten metal and molten glass, but "infra-red rays have no specific action on the tissues analogous to that of abiotic rays. Any effect due to them is simply a matter of thermic action, and such rays are in the main absorbed by the media of the eye before reaching the retina." All of which leads to the conclusion that the deleterious results which have been noted are the heat effect without regard to wave length. The results produced by excessive heat may be in the form of lens changes so frequently seen as cataract among glass-blowers, and described more fully on pages 66 and 67. Again, the cornea may be affected, and permanent injury to the iris and retina be accomplished, though the latter only under extreme conditions.

Arc welders must be protected not only from the intense light and heat, but also from the fine particles which fly off from the electrode. There is more or less tendency to oxidation and formation of cinder, and the imprisoned air, bursting its way out of the contact surface, may be the cause of just as serious an injury as were the cinders of the former hand process of welding.

Case: Charlie Biehler and John Grohol had been working together for twelve years at the Pittsburgh Plant of the American Locomotive Company. Both men were skilled in erecting shop work, and had goggles and had used them. Biehler was caulking an electric weld. A small particle of iron broke off and hit Grohol in the right eye. As the Company's Safety Bulletin on the case reads: "Had his goggles been on, this bulletin would not have been issued. The Company employed specialists to save his eye, but science failed. Men!!! Profit by Grohol's misfortune. Wear your goggles and don't take the chance. Grohol is now blind in one eye."

There are certain strains produced in the neighborhood of the weld irrespective of whatever careful attention may have been paid to the heating of the metals. In order to relieve these strains it is customary to hammer all welds immediately or as quickly as the hardening process will permit, the idea being to expand the hot metal at the same rate at which it is contracting. Welds that are not hammered may show microscopic checks and

are of low tensile strength. When the operator first starts to hammer his weld there is a certain amount of surplus metal and slag which is forced aside by the blow of his hammer, and after the metal solidifies there is also considerable scale formed, which, with the continued hammering, will fly in all directions.

Recommendations: Welding and cutting by high temperature media should be done in a room separated from other workplaces. This segregation confines the risk to the welders and cutters. So far as isolation is concerned, dependence should not be placed upon the canvas curtain "walls" seen occasionally in use for this purpose. Wear and tear will, within a short time, make such curtains practically worthless as a means of protecting other workmen from the glare.

The use of goggles will offset the hazards enumerated, and will eliminate danger from splashes of molten metal, flying sparks, cinders, etc.

There is no doubt as to the need for providing employes with colored goggles which will protect their eyes from the radiations from superheated metals and high temperature welding media, irrespective of whether or not the results from such exposure would otherwise prove permanent or but temporary. Such severe discomfort may follow a very brief exposure, that protection is essential. Without it there result marked inflammation of the mucous membranes of the eyes, annoying after-images, light-flashes, headaches, and temporary blindness, with consequent loss of time and wages. The permanent effects resulting therefrom have already been described.

Goggles in various dark colors are very generally made use of, though frequently but little attention has been paid to the absorptive qualities of the glass. Dark-blue, smoke, and red glasses are often employed. Unfortunately, these colors are far from being effective.

That which is most frequently in evidence is the cobalt blue, which may be cited as a typical example of improper color for the purposes for which it is intended. It gives but a hazy view of the furnace interior and molten metal, and is *not* effective in absorbing those radiations which are, at least, excessively fatiguing to the eye.

Fig. 18.—Mask used by electric welders and scrap burners. Made of sheet brass and goggles. Weight is carried on shoulders by means of the wire stirrup. National Tube Company.

It is an interesting fact that while clear glass is 46 times more transparent to visible light than is cobalt-blue glass, yet the latter is more transparent to the ultra-violet rays (the invisible radiations) than is clear glass of the same thickness.

The requirements of goggles for protection in these operations are that they shall provide sufficient reduction of the intensity of the light, be effective in absorbing the ultra-violet rays, keep the eye cool, and transmit as much as possible of the visible spectrum without color distortion. That the color of the goggle itself be inconspicuous is an advantage—though of least importance.

Valuable data on this subject are given in a recent publication entitled "Glasses for Protecting the Eyes from Injurious Radiations," by W. W. Coblentz and W. B. Emerson (Technologic Paper No. 93, United States Bureau of Standards, Washington).

Data are given by these investigators showing that, of the infra-red rays (heat-rays) emitted by a furnace heated to 1000° to 1100° C. (1) about 99 per cent. are obstructed by "gold-plated" glasses, (2) about 95 per cent. by sage-green or bluish-green glasses, (3) about 60 to 80 per cent. by very deep black glasses, and (4) about 60 per cent. by greenish-yellow glasses. At higher temperatures these data would be somewhat different.

For working molten quartz, operating oxy-acetylene or electric welding apparatus, searchlights, or other intense sources of light, it is important to wear the darkest glasses one can use, whether black, green (not including gold-plated glasses), or yellowish-green, in order to obstruct not only the infra-red but also the visible and the ultra-violet rays. For working near furnaces of molten iron or glass if considerable light is needed a light bluish-green or sage-green glass is advised.

Mention has been made of "gold-plated glasses." These appear to be the most effective means yet devised for shielding the eyes from the infra-red rays. Regarding them, Coblentz and Emerson state:

"Metals are the most opaque substances known for infra-red radiations, while in the visible spectrum gold has a region of low reflectivity and great transparency in the region of 0.5 μ. This property would naturally suggest itself as a means of eliminating all the infra-red by covering white spectacle glass with a thin

layer of gold. The high reflective power (metallic reflection of 60 to 80 per cent. as compared with the vitreous reflection of about 4 per cent. from glass) makes it desirable to mount these gold-plated glasses in a hood ('goggles') which prevents reflection of light from the rear surface of the film into the eye."

Unfortunately, the cost of such glasses puts them as yet rather out of the range of availability for industrial purposes, and, moreover, the effects produced in looking through them "did not appear quite so pleasing as through the sample of Crookes' sage-green ferrous glass. In the latter the transmission is twice as great (44 per cent.) in the visible with but little addition of infra-red."

Verhoeff and Bell state that for "protection of the external eye against extreme heat few glasses except such special ones as have recently been devised by Crookes are very effective."

Crookes developed numerous shades which are effective in varying capacity. The glass which, in his own opinion, provides most satisfactory protection is sage-green in color, which, in a plate 2 mm. in thickness, is opaque to 98 per cent. of the heat radiation, absorbs the ultra-violet rays beyond any possibility of their proving objectionable, and at the same time transmits 27.6 per cent. of the incident light.*

Aside from the Crookes glass, the grayish-green glass developed by Fieuzal, the amber, Hallauer, Euphos, Enixanthos, Hygat, and Noviol—all of which, under the names designated, approximate one another in their absorptive powers, and are effective in cutting off the ultra-violet. They run in color from a yellowish to a somewhat bluish green, and occur in various shades. The deeper shades of any of them cut off the spectrum completely at about the beginning of the ultra-violet and weaken it well into the violet.

The choice between them lies mainly in the matter of taste as regards their particular color and absorption in the visible part of the spectrum. The yellow-green would seem to be the one most satisfactory from the latter standpoint.

For further necessary protection where exposure to heat is

* "The Preparation of Eye-preserving Glass and Spectacles," Sir William Crookes, O.M., F.R.S.

great and continuous there is a wide assortment of masks designed for that purpose. The one illustrated on page 48 is made of composition board with aluminum parts, and fits on small hinges and pivots over a circular band surrounding the head. This arrangement enables the worker to throw the mask back without removing it should he be temporarily engaged in work not requiring eye protection. The intent of the V-shaped prow is to deflect heat waves and gases.

For outdoor welding, such as work on steel rails, there is a simple protective device in the shape of a small box beneath which the work is accomplished. Correctly tinted glass windows in the box enable the welder to safely watch his work and protect passers-by from injury from the light source or from flying chips and sparks.

MOLTEN METAL HAZARDS

Case: Threatened with the loss of his sight, Lee C——, thirty-one years old, is at the M—— General Hospital, suffering from severe burns about his face. C—— is an employe of the M—— S—— Company. While at work yesterday morning some molten steel ran into some wet sand and flared up in his face.—*Baltimore, Md., American, October 6, 1916.*

Case: A serious accident befell A—— G—— an employe of the S—— Company last Saturday afternoon, and he is now at the W—— Sanitarium. G—— worked in the molding department of the foundry and some hot metal being poured into a form, spattered up and struck him in the left eye. His physician fears that the sight is permanently destroyed.—*Catskill, New York, Mail, March 21, 1916.*

As indicated by the cases quoted, one of the chief hazards to eyesight in metallurgic operations is that due to burns from the splashing of the molten metal. As has been mentioned in the preceding section, exposure to the intense light and heat of metal in its liquid state may also be productive of disability, which, while not permanent in nature, will cause considerable discomfort and loss of time.

To the layman the processes involved in the manufacture of iron and steel may seem so complex as to discourage even a cursory investigation. For all such there is strongly recommended the reading of a recent publication entitled "The Story of Steel," issued by the United States Steel Corporation. It may fairly

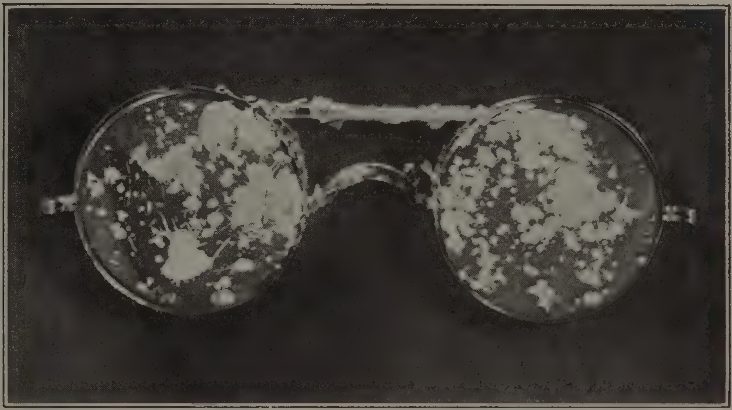

Fig. 19.—These goggles saved a workman's sight when hot babbitt he was pouring exploded. American Bridge Company.

Fig. 20.—Pouring babbitt—single hand ladle. Carnegie Steel Company.

be said that few popular novels portray a more fascinating and readable romance than is given therein.

As an introduction to this section on eye hazards in metallurgic operations, certain excerpts from the publication referred to are reproduced, with the permission of the Steel Corporation. These quotations will, it is hoped, indicate the magnitude of the safety problem which confronts the industrialist and engineer in that industrial field.

THE BLAST FURNACE

Iron ore, as it is found in the ore beds, is composed of iron and oxygen, with certain impurities. It is the purpose of the blast furnace to rob the ore of its oxygen, flux out the impurities, and leave the iron. The early makers of iron discovered, doubtless by accident, that if they sprinkled iron ore upon red-hot coals, raked other red-hot coals over the ore, then blew air upon the fire, the ore melted and hard and durable substance was formed. Even now, in almost as crude fashion, the South Africans make steel. They fashion a plate of clay pierced with holes and bake it hard. Then upon the plate they place ore and charcoal, kindle a charcoal fire underneath, and blow it with bellows until the ore melts and trickles down through the holes into a clay container, where fire is blown upon it until the smelting process is complete and it is ready to be hammered into rude tools and weapons.

On the same principle is the modern blast furnace—the monster that eats up 2000 tons of raw materials a day. All the iron that is used for steel has to pass through the blast furnace, where it is smelted with coke and limestone.

Most of the accidents that made the steel industry notorious in the early days occurred near the blast furnaces, but safety devices have so effectively chained these monsters that nowadays there are few accidents. The furnace cannot now spew its hot contents, even when a fresh charge of raw material is being crammed down its great throat, for a piece of hollow iron like a huge bell is lowered down its throat while its mouth is being filled, and a second bell is clapped over its mouth before the first one is loosened to allow the charge to drop down into the huge maw.

In the old days the molten metal occasionally ate through the shell of the furnace and dropped down to touch water and was hurled in every direction by the force of its self-generated steam. The modern blast furnace has a water-cooled shell which reduces the danger of these breakouts; and at all points,

especially at the top and bottom of the furnace, are guards and safety devices that practically eliminate the possibility of accident.

A blast furnace is operated continuously. Work may slow down—may cease—in other departments of a steel mill; but day in and day out the blast furnace keeps at its work of turning out pig iron, so named because the molten metal used to be run out from the furnace into large, trough-like molds called "sows," from which it trickled into smaller molds or "pigs," and was left to cool. Nowadays, unless used directly in the steel plant, the metal flows into molds fastened to an endless conveyor and run through water to cool it, or it is left to cool by natural process.

Huge stacks called "stoves" heat the air for the furnaces. They are 100 feet high and something over 20 feet in diameter, lined throughout with brick. Gas from the blast furnace is burned in the combustion chambers of these stoves. The heated products of combustion pass through the checker work for an hour or more, heating the bricks to their full heat-absorbing capacity; then the gas is turned off, and air blast, supplied by the blowing engines of the blast furnace, is passed through these stoves in the opposite direction.

This air absorbs the heat from the bricks and then enters the blast furnace through pipes called Tuyeres, at a temperature of 1200° to 1400° F. In the furnace this heated air passes over the coke, burning it and creating an intense heat in the hearth or bottom part of the furnace. The oxygen is taken from the ore, the carbonic acid from the limestone, the limestone and ore are fluxed, and the metallic iron trickles down into the hearth through the slag which is formed in this process.

Every four or five hours the tapping hole is opened and the liquid iron is tapped out of the hearth and run into huge ladles in which it is carried to the steel furnace or cast in the pig machine.

It is hard to realize how much air a blast furnace consumes. Each of those at Gary, Indiana, consumes 36,500 feet of air a minute. Yet the air that is fed to a furnace must be carefully controlled—quite as carefully as the ore and coke and limestone, because a very slight thing will upset the digestive processes of a furnace. To illustrate, occasionally a small lump will fasten itself—"freeze" or harden—on the inside. The lump catches other particles, which adhere to it until a great mass is formed. The air coming from the stoves must then be heated to a very high temperature, to assist the efforts made to melt out this semiliquid mass.

THE OPEN-HEARTH FURNACE

At the first sight an open-hearth furnace looks like a baker's oven. But when the visitor puts on a pair of colored spectacles such as the workmen use and peers through the water-cooled door, he finds himself looking across a great pool, 35 to 40 feet long and 15 feet wide, filled with bubbling, white-hot metal, tinted here and there with delicate shades of pink and blue. It seems more like candy cooking than like steel, but during the ten to twelve hours of cooking in the intense heat of the gas the mass is converted into steel.

Metallurgists experimenting with iron ore long ago found that a mixture of raw iron, limestone, and scrap iron heaped on a shallow hearth and heated to a high temperature by gas flames would at the end of six hours be smelted into steel—very good steel, too.

This open-hearth process is called an "open-hearth heat," and each time such a heat is tapped the world is richer by 50 to 100 tons of steel.

This explains why so little scrap iron is found lying about a plant. The scrap is used in the open-hearth process—not to get rid of it, but because it is needed. Before being sent to the furnace all the large scrap is gathered into a space enclosed by heavy screening where a huge ball is raised high by a powerful magnet, released and dropped down upon the pieces of old iron and steel, smashing them into convenient sizes for the furnaces. The broken scrap is then heaped on small cards with removable boxes and started for the open-hearth furnace. From another part of the plant yard a trainload of ladles filled with molten iron is started toward the mixer—the gathering point from the hot metal as it comes from the blast furnaces. Into this receptacle, shaped like a huge teapot, the heats from the different furnaces are poured. Here they are equalized—made uniform in quality—before being poured out again through the giant spout into ladles and borne by cranes to the open-hearth furnaces.

Meanwhile, on the open-hearth floor, a supply of finely ground dolomite has been piled before the long line of furnace doors, and as soon as a heat has been discharged, laborers shovel in the dolomite, which melts like glass and fills any holes that may have been burned through the lining, forming a solid bottom for the fresh charge. Then the charging begins. First, from the trainload of scrap which has been brought alongside the furnaces an electric charging machine lifts box after box, pushing its burden through the door and tilting the contents into the furnace. Then an overhead crane brings from the mixer a huge ladle, swings it

aloft, and pours the molten iron into the furnace. And from time to time during the charging a laborer throws in a shovelful

Fig. 21.—Pouring from bottom ladle. Only the operator is wearing protective goggles.

of limestone. What one really sees bubbling on the surface of the furnace is the melting limestone gathering to itself the impurities of the steel and forming them into slag.

Steel, as one sees it in finished tools or rails, undergoes many changes between the ore and the finished product. The blast furnace smelts and refines the ore; but it is still iron as it comes from the blast furnace, with 4 per cent. of carbon and 0.5 to 1.5 per cent. each of manganese and silicon. These ingredients, and certain amounts of sulphur and phosphorus, are considered impurities, though carbon in limited quantities gives hardness, and manganese toughness, to steel. The percentage of impurities can be well regulated in an open-hearth heat. It cannot be regulated as fully in the Bessemer process. It is regulated in both cases at the end of the heat by adding the necessary amount of carbon, manganese, etc., either in the molten or solid state. This explains the additions of spiegel, ferro-manganese, ferro-silicon, etc.

To watch the tapping of an open-hearth "heat" is an interesting experience. At the rear of the furnace is a great open space. Overhead is an electric crane, equipped with an extra steel-and-asbestos shelter having an extra power controller, for the craneman's use in case of accident, for all these operations are most carefully safeguarded. At the side farthest from the rear of the furnace is a pouring platform, upon which the molten metal is poured into molds from the ladles carried to the platform by the overhead crane.

One of these great ladles is brought to the rear of the furnace when a charge is ready for tapping. While it waits for its load a gas-flame is kept burning inside it, to dry out every trace of moisture. More than once a few drops of water under molten steel have caused a fatal explosion. When the time comes for tapping, a workman, quick and sure as a cat, poises himself in a niche provided for the purpose and jams a steel bar through a clay-plugged hole at the base of the furnace. Out tumbles the steel into the waiting ladle. Scattering a trail of many colored sparks and glowing like a stream of gold, it lights up the whole mill. Higher and higher it mounts, until the ladle is full and the slag, loaded with impurities, overflows and congeals on the outside. Then the craneman lowers his chains, and, catching the ladle by the lugs, swings it over the pouring platform, where other men tap it and pour the contents into ingot molds mounted upon cars.

THE ELECTRIC FURNACE

It is the squat little electric furnace that makes the best steel of all, because it can be controlled so accurately. The high-grade alloy steels—vanadium, chrome-nickel, and manganese steel—come from this little fifteen-ton furnace, which usually has

half of a great building to itself, while in the other half other furnaces are busy preparing the metal to feed it. A crane pours the metal into the furnace. Gas is not used for heating; an electric arc does the work instead. This arc is struck between the metallic charge and large electrodes capable of conducting tremendous currents, which are passed through the top of the furnace down to the surface of the slag. The electric circuit of which they are a part is completed through the metallic charge in the furnace, so that an arc is formed at the point of contact of the electrodes with the slag. "The rest is not difficult," says the furnace manager, "by varying the materials used in the formation of the slag, that is, simply by using different kinds of flux, all the steel's impurities can be coaxed out to join hands with their chemical affinities. Alloys can be added at pleasure. And when the metal is ready, the crane spots a ladle in place for it and then carries the ladle off to a pouring platform, where it is poured into ingot molds just like other steel."

All the processes of steel making converge in the production of the ingot. The ingot is to steel what bar gold is to currency. It is the common denominator—the standard by which the production of steel is measured. And when the molten metal has been poured into ingot molds, the intrinsic business of making steel is ended. Thereafter it is only a matter of fashioning from the ingots the shapes desired.—*The Story of Steel.*

In the iron and steel manufacturing processes which have here been described the chief eye hazards are (1) those due to exposure to the great light and heat of molten metal, and (2) to burns from the explosions. Eye accidents resulting from flying scale or other foreign substance which may lodge in a workman's eye are also frequent in subsequent operations.

The remarkably gratifying reduction of accidents in this industry (see Fig. 49, p. 142) has been effected by the provision of modern strong furnaces, accident-proof and fool-proof so far as possible in the light of present construction knowledge, by the provision of hoods and exhaust systems where necessary for the removal of dusts, fumes, and gas; by the provision of guards on dangerous places in mechanical operations and by the provision of goggles for all workers exposed to hazards which make such protection advisable. The use of these devices by those whom they are intended to benefit has not been accomplished without the most extensive expenditure of time and money in educational

work done by the safety directors of the various steel companies.

Recommendations: Furnace men are continually exposed to the excessive light and heat from the molten masses of iron or steel. The same danger from these light and heat sources confronts those engaged in tapping, pouring, and casting, and the general recommendation is given that all who are thus exposed shall be provided with colored goggles for the elimination of the injurious rays in their particular occupation. (For color suggestions, see page 52.)

Fig. 22.

The cobalt-blue glass which has been used so commonly by furnace men is *not* effective in providing the protection needed. Those who have worn blue glasses have often become so accustomed to watching the molten metal through the blue that it is an extremely difficult matter for the safety director to bring about their adoption of any other color of glass. While protection from the intense light is important, it is not so vital a matter as is protection from the excessive heat engendered in these operations. As to the effects of this, and the nature of protection advisable, the reader is referred to the section on Radiant Energy in Arc Welding and in Molten Metal, page 47.

The metallic parts of the goggles which come in contact with the face should be covered with a non-conducting material, such as tubing or leather, to offset heat, and should be of a design which permits complete adjustment to individual facial contour.

In the foundries visited in and around Buffalo it was rarely that goggles were found in use among those employes who were exposed to eye burns from explosions of molten metal, flying sparks, splashing, et cetera. The usual excuse given was that

the goggles "steamed up" and interfered with vision, and were in themselves a menace because they would then "prevent a man's seeing where to run in the event of an accident when life itself might depend upon a quick get-a-way."

As has been stated frequently by other writers describing protective devices for industrial workers, the use of the glycerin pencil, or a sweat pencil of some compositions of a similar character, is of material advantage in preventing the steaming of

Fig. 23.—Operatives wearing masks and goggles for protection from intense light and heat. Otis Elevator Company.

glasses. A sweat-band around the forehead or attached to the top of the goggles to absorb the moisture and prevent perspiration from running into the eyes, will also help to relieve the difficulty.

Employers are frequently discouraged by the reluctance of their employes to use protective goggles in foundry work. The solution of the difficulty would seem to depend on continued edu-

cational work and the enforcement of regulations regarding the use of goggles in these dangerous occupations.

Serious accidents may occur from the spattering of molten metal in filling and in emptying a ladle. To avoid this when filling from a continuous stream of metal, the stream should be cut into from the front, instead of from its back. Ladle lips should be so designed that a smooth flow out in a concentrated stream is also secured.

Explosions are caused by the molten metal coming in contact with moisture in a ladle. Thorough drying of ladles will prevent such an occurrence. Large ladles are frequently dried in core ovens. This prevents fouling of the foundry air by smoke which would result if the drying were accomplished by having fires built in the ladles, as is still done in some foundries, or by attempting to dry large ladles on a heater intended only for the single-hand ladles.

"When the lining and drying of ladles are under control of one man, a better opportunity is afforded to inspect all ladles thoroughly every day. Inspection for cracked or thin bowls, loose rivets, eroded shanks, defective welds, imperfect balancing, as well as daily attention to safeguarding the gear mechanism, is thus concentrated under one man's watchful eye. Moreover, the foreman himself can give better oversight to this department of the work when one man (not a score or more) is delegated to the task. This method also tends to insure storage of all ladles, large or small, in a dry place instead of in damp corners or on wet sand, where they are apt to rust. Large ladles which remain unused for long periods should be stored on supports to provide air space and prevent absorption of moisture from the ground."*

Not only must dampness or moisture be avoided in the ladle, but likewise in the crucibles and in the molds. When exposed to high temperatures, if the crucible contains moisture, there is rapid condensation of the moisture into steam, which causes explosions and breaks down the crucible walls in its effort to escape. The storing of crucibles in dry, heated places before using, and when not in service, and the avoidance of their ex-

* "Safety in the Foundry," Alexander.

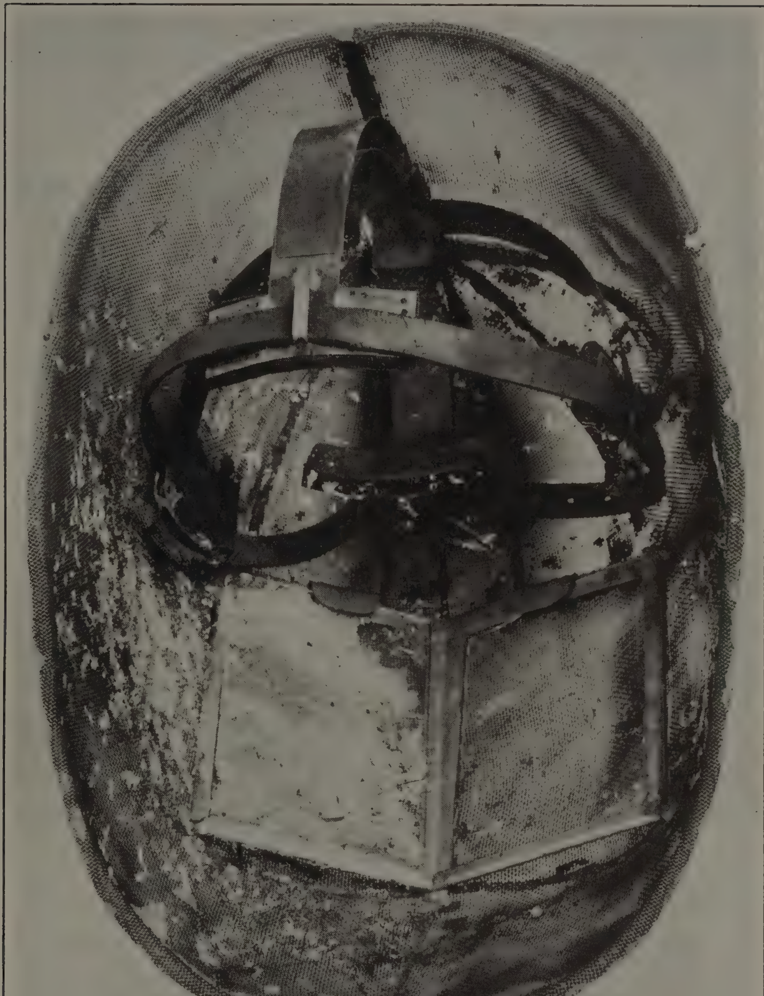

Fig. 24.—Interior of babbitting mask showing the left glass cracked and completely coated with molten metal, demonstrating its efficacy. United States Steel Corporation.

posure to dampness in the fuel used in storage oven or melting furnace will maintain them in safe condition.

Turn-over pig molds when not in use should be left upside down to prevent their accumulating moisture.

GLASS-BLOWERS' CATARACT

It has been recognized for many years that glass-blowers appear to be particularly susceptible to a special form of cataract, which begins in the posterior part of the lens, the remainder of the lens for a long time remaining clear. The cataract most frequently appears in the left eye, which is more exposed to the molten mass. The length of time necessary for its development is undetermined, though it is a matter of years.

Glass-blowers are constantly gazing into molten masses of a temperature from 1200° to 1400° C., but as the spectrum of a non-gaseous body at this temperature does not include any of the so-called "abiotic" radiations (*cf.* page 45), the popular theory of injury from ultra-violet radiation may be completely eliminated.*

Regarding the theory that the development of cataract among glass workers is due to long-continued exposure to excessive heat, rather than light rays, it would appear that only a small percentage of energy transmitted from the source of the temperature of a glass furnace reaches the posterior part of the lens and "the effect of this on the lens would be more than offset by the greater absorption of the anterior layers. (Between 80 and 90 per cent. of the energy will be absorbed by the cornea alone, and not more than 3 or 4 per cent. be stopped in the lens.) Regarding the further distribution of temperature in the eye resulting from the intense radiation, Verhoeff and Bell add:

"The iris, which strongly absorbs most of the energy which falls upon it, especially if strongly colored, to a certain extent screens the front surface of the lens behind it, especially since the circulatory system in the iris tends to prevent its temperature rising materially unless the access of energy is above the rate at which circulation can take care of it. At the rear of the lens the

* "The Pathological Effect of Radiant Energy on the Eye," Verhoeff and Bell, p. 735.

vitreous with its fibrillated structure effectively prevents, like all such substances, the existence of convection currents. Just what the net effect of the structure is upon the steady distribution of temperature when the eye is exposed to radiation cannot be quantitatively determined, and while undoubtedly the heat reaching the rear of the lens from the energy transmitted to that point, or received from that taken up by absorption in the anterior part of the eye, cannot readily escape and hence tends toward concentration, it seems somewhat doubtful whether this cause alone could determine the starting of cataract at the posterior cortex.

"We are inclined to attach more importance to the suggestions of Leber* that the effect is a secondary one, due to the loss of water in the drain produced by the heat on the front of the eye and elsewhere, and to that of Parsons† that the malady may occur through perspiration and malnutrition due to interference with the functions of the ciliary body by the heat. The development of glass-blowers' cataract is so slow that it is quite hopeless to reach its cause experimentally, but from the facts here stated we incline to the opinion that these secondary effects of radiation are more important in producing it than the specific action of the radiation in producing localized effect at the posterior cortex. In any case it is perfectly clear that abiotic radiations are not concerned, and have nothing to do with the matter."

The most satisfactory colors of goggles recommended for the protection of the external eye against extreme heat are given in the discussion of this subject on pp. 52 and 53. In extenuation of the usual reluctancy of glass-blowers to use goggles, it must be remembered that these men are exposed for long periods to high temperature; that they are for this reason if no other constantly drinking huge quantities of water or liquor and perspire excessively as a result thereof. It can scarcely be wondered at that they are more willing to run the risks attendant upon lack of protection rather than wear goggles.

* Leber: "Die Ernährungs und Cirkulations Verhältnisse der Auges," Graefe-Saemisch, 1903, p. 454.

† Parsons: "Affections of the Eye Produced by Undue Exposure to Light," Seventeenth International Congress of Med., Sect. 9, 199, 1913.

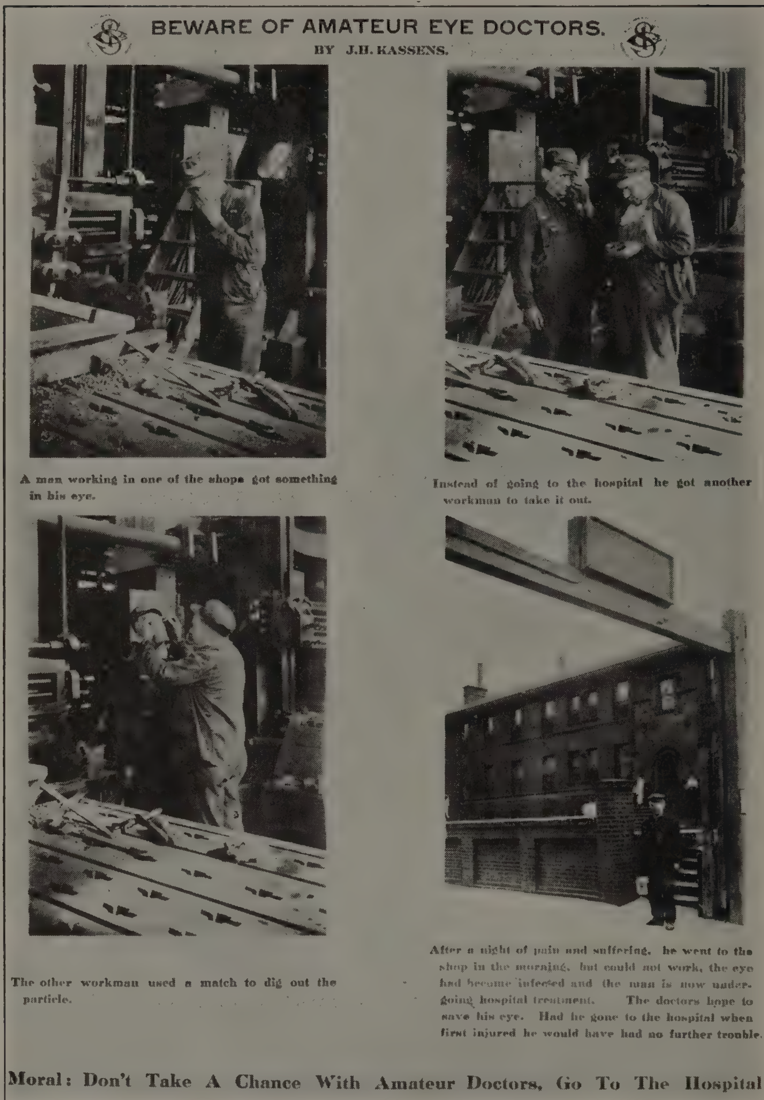
BEWARE OF AMATEUR EYE DOCTORS.
BY J.H. KASSENS.
A man working in one of the shops got something in his eye.
Instead of going to the hospital he got another workman to take it out.
The other workman used a match to dig out the particle.
After a night of pain and suffering, he went to the shop in the morning, but could not work, the eye had become infected and the man is now undergoing hospital treatment. The doctors hope to save his eye. Had he gone to the hospital when first injured he would have had no further trouble.
Moral: Don't Take A Chance With Amateur Doctors, Go To The Hospital

Fig. 25.

THE REMOVAL OF A FOREIGN SUBSTANCE FROM THE EYE

Case: Roscoe Markgraf, of Antigo, got a sliver of wood in his eye. Instead of reporting his accident and going to a doctor he neglected the eye for two days. Blood poison set in, and the eye had to be removed.—*Bulletin No. 423 of the National Safety Council.*

Thousands of cases of infected eyes, many of them damaged irreparably, have been caused by the carelessness of workmen who have neglected a condition such as that mentioned in the above case report, or who have permitted a comrade, at the time of injury, to remove, or attempt to remove, a foreign substance which has lodged on or in the eye. Of all hazards to eyesight, this is one which is perhaps most frequently encountered. Its potentialities for impaired vision, or total loss of sight, are so great that every means tending to its elimination should be adopted.

Numerous micro-organisms which have been found to cause infection of ocular wounds are mentioned by Würdemann in "Occupational Injuries and Diseases of the Eye." Certain of the most dreaded systemic diseases may find a point of entrance through a tiny wound thus caused in the cornea, the individual being in all respects entirely normal and in good health.

For example, a fine chip of steel or emery has lodged on a workman's eye at some time when he has not been wearing his protective goggles. The offending substance may perhaps be seen on the cornea. It is so plainly visible, and there is so little pain or discomfort, that there seems to be no reason for applying to the hospital, company doctor, or nurse for relief. A fellow-workman who has established a reputation as "the shop oculist" is therefore requested to remove the chip.

He, perhaps, may use his soiled handkerchief, a corner of which is rolled to a point and then moistened in the mouth. If the bandana is not in evidence, a match which has been carried around in a sweaty pocket, or perchance a toothpick, is requisitioned.

The endeavor to extract, or push out, the chip from its lodging place follows. If it has become embedded in the cornea,

considerable pushing and probing are necessary before it can be removed. The surface of the eye is abraded, and from the edges of the unclean probe microörganisms are transferred to the wound. Infection results, with possible subsequent loss of one or both eyes.

There still are to be found an infinite number of workplaces which boast of their "expert in the removal of chips" from the eyes. With some a long hair suffices for the process, looped and moved around under the lid, whose inner surface as well as that of the eyeball is thus raked over in the endeavor to remove the offending particle. Occasionally one finds another type of expert at this work—the man who can remove a foreign substance with his tongue.

The illustration in Fig. 26 shows a collection of a few of the instruments which have been used by "shop oculists" for the removal of particles from the eyes of fellow-workers.

The potentialities of disaster which lie in this kind of procedure should be sufficiently awful to put a stop to the effort if workmen could but understand their significance. The point of a probe which has been moistened in the diseased mouth of a workman who perhaps is suffering with a long-standing case of some venereal disease which has produced lesions in the mouth may ruin the sight and life of an entirely innocent fellow-worker. Moreover, there are always existent in the normal eye bacteria which find opportunity for development of serious infections through abrasions which might result from the unskilled use of even a thoroughly sterile probe, and it is of utmost importance that any operation of this nature should be done by an oculist or physician who may have the opportunity to maintain observance of the eye for possible later developments that might prove disastrous.

Indicative of the damage resulting from infections are the findings of the Industrial Commission of Ohio, published in Report No. 29 of its Department of Investigation and Statistics. Of 74,525 industrial accidents for which awards were made by that Commission for the year ending June 30, 1915, infection was reported in connection with 7072 of this number, or, in other words, approximately one out of every ten industrial injuries became infected.

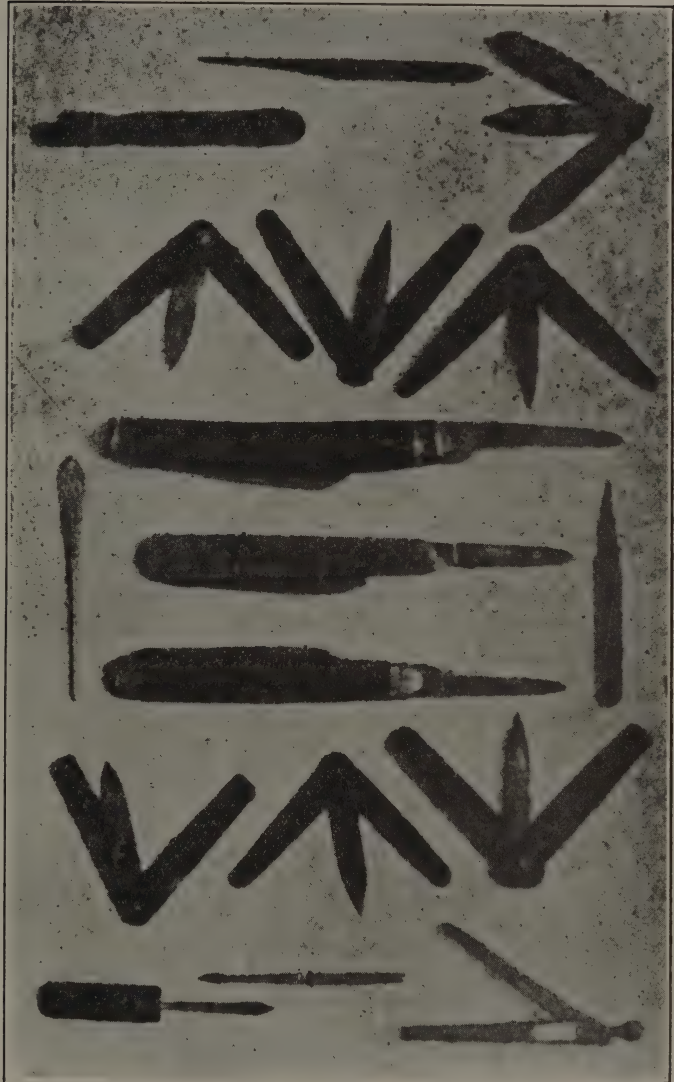

Fig. 26.—Articles which have been used by "shop oculists" in removing foreign particles from the eyes of their fellow-workmen.

Of the 1643 cases of permanent partial disability, 161 (9.8 per cent.) were caused by infection. There were 255 cases of total or partial loss of vision in one or both eyes. Of these, 46 (18 per cent.) were due to infection.

Of 71,400 cases of temporary disability allowed there were 8000 cases due to presence of a foreign body in the eye; 519 (6.48 per cent.) of these were attended by infection.

Very little information is available covering the time and wages lost due to infection. It is undoubtedly great. In the last Industrial Insurance Report of the State of Washington it is shown that 1029 injuries resulted in infection. This number is approximately 7 per cent. of all injuries reported; 59 of these were infections of the eye. The number of work-days lost as a result of these eye infections was 1024—an average of 17.3 days lost per case. Fourteen of these became permanent partial disabilities. The total compensation awards for the 59 cases amounted to $10,446. As usual, the chief causal factors were foreign substances lodging in or on the eye, bruises, punctures, scalds, burns, and cuts.

Recommendations: Any workman who sustains an injury of this nature, no matter how slight it may seem to be, should go at once to the company hospital, physician, or nurse, if such there be. There should be "first-aid kits" in charge of foremen or office men who have been instructed in their use, and such persons only should be the ones consulted in any emergency of this nature if no physician is employed by the company.

"For the removal of dust and dirt the lids should be gently separated and the eye flushed with boric acid or normal salt solution, followed by a couple of drops of a 10 per cent. argyrol solution or the application of a small bead of bichloride salve, bandaged, and the man sent to the company doctor. This rule also applies to any injuries in which the foreign body has embedded itself in the eye or penetrated it.*

"All cases of penetrating injuries should be sent to the doctor. Frequently the injured man has so little discomfort and so little interference with vision, he will not even apply for first aid, and if he does do so, will refuse to go to the doctor. As a result many

* "The Eye in Industrial Accidents," Nelson M. Black, M.D.

eyes are lost which otherwise might be saved. If the penetrating body is small, it is often impossible for the injured person to tell whether there is anything in the eye or not, and the ordinary means of examination used by a doctor may not be able to determine it. In such cases it is of the greatest importance to determine by means of the *x*-ray if there is a foreign body within the globe, for if foreign bodies are not removed, they will eventually destroy vision or cause loss of the eye."

First-aid kits are now marketed by a number of the large medical and safety supply houses, and such safeguards should be available in every shop. Sterile gauze and bandages, a syringe for flushing the eye, boric acid, argyrol, and the other accessories of first-aid equipment should be available and ready for emergency use.

If there is one regulation above all others which should not fail of being in effect in every shop, factory, and workplace of any nature whatsoever, it is that there shall be no attempt made on the part of any workman to remove from the eye or eyes of a comrade a chip or foreign substance of any kind which may have accidentally lodged therein. Many corporations have already adopted such a ruling, the penalty for non-compliance usually being immediate dismissal of the offender.

GAGE-GLASSES

Case: Anthony Boehm, thirty-seven years old, of Irondale, was brought to the East Liverpool Hospital yesterday, where a piece of broken glass was taken out of his left eye by Dr. J. W. Chetwind. Boehm was suffering greatly as the result of the particle of glass flying into his eye in an accident Thursday afternoon, when the water glass on a steam boiler broke. He will lose the sight of the one eye, and it is possible that the other will also be affected. Boehm was employed as stationary engineer by the Eastern Ohio Sewer Pipe Works. Thursday afternoon he happened to be standing close to the steam boiler at which he was working when the water glass on the boiler exploded without warning. It was at first thought that the injury was only a minor one, but it rapidly became serious.—*East Liverpool, Ohio, Tribune, May 22, 1915.*

The effort to safeguard workmen from a bursting gage-glass appears to have been sadly neglected in and around Buffalo. With but few exceptions guards on the gage-glasses were lacking.

When there occurs such an accident as the one cited in the

foregoing case, steam, hot water, and particles of glass are blown out from the broken glass, and should the engineer or any other employe happen to be standing near at hand, or facing the gage-glass, he will in all likelihood sustain serious burns and cuts. While accidents of this nature are comparatively infrequent, the statistics of the Massachusetts Employees Compensation Insurance Association show that during a recent year seven men in that state lost the sight of both eyes from this cause, and one workman lost the sight of one eye.

The breakage of a gage-glass is frequently traceable to misalignment of the connections, defects in the glass, and the effect of erosion caused by the condensation of steam, and apparent at the top of the glass.

Fig. 27.—Upper ends of new and worn tubular glasses.

Recommendations: In the Fidelity and Casualty Company's booklet, "Industrial Accident Prevention," the following suggestions regarding this hazard are given:

"The danger to the attendants from the bursting of gage-glasses naturally suggests the use of a safety device in the form of a guard. But the use of a guard makes it less easy to keep track of the water-level, and the danger of low water through wrong readings is thus encountered.

"When the condition will permit the use of a guard, either of the following arrangements will prevent the glass from flying and will deflect the steam and water to some extent, thereby enabling a safer approach for closing the valves:

"1. Place a V-shaped or semi-circular shield of wire-glass in front of the gage-glass.

"2. Enclose the glass in a metal shield which is slotted to permit observation of the water-level.

"The use of pendent chains from lever-operated valves will also be of assistance in closing after breakage. In case of breakage, close the water-valve first. When a new glass has been inserted, step out of range and open the water-valve first."

The gage glass, with protective features, as illustrated on this page, shows a device invented by one of the Superintendents of Motive Power of the New York Central Lines, and has

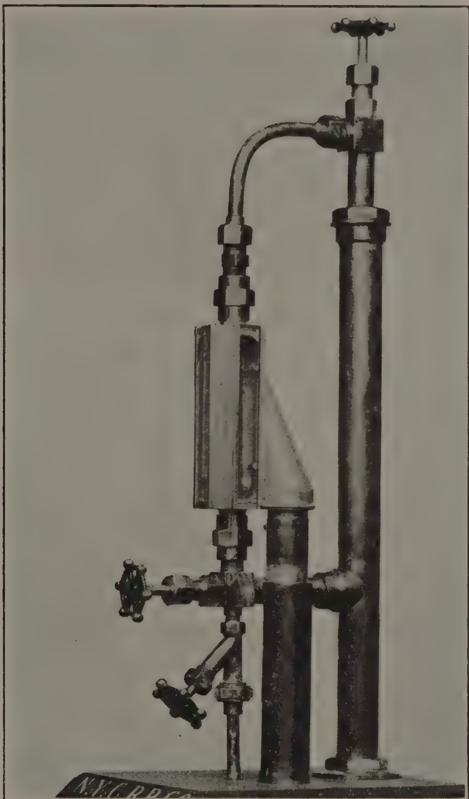

Fig. 28.—Water glass shield. New York Central Lines.

been adopted as standard by that system. The blowout pipe at the rear extends downward through the floor of the locomotive cab and is designed to carry away broken glass, water, and steam should a breakage occur.

Certain states have adopted the following recommendations with regard to this hazard:

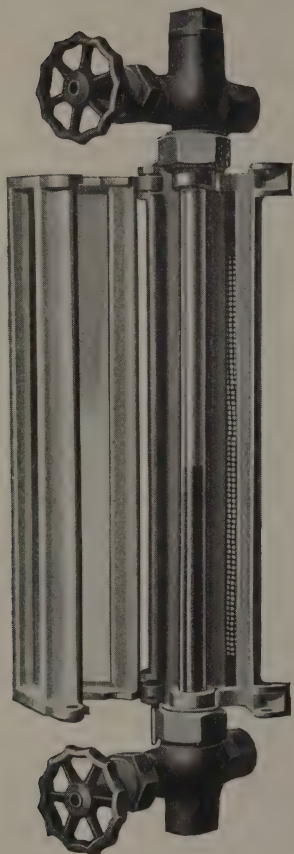

Fig. 29.—Detail of water glass with protector open. When closed, danger is eliminated without affecting visibility of water-level.

Each water-gage-glass guard located within ten feet of floor or firing platform shall be equipped with a guard which constantly interposes a transparent shield between the gage-glass and the workman. This shield may consist of heavy plate glass or wired glass, but shall be of sufficient strength to withstand the shock of a bursting gage-glass. (Plain wire netting is not approved for this service.) The guard shall be so arranged that it is not necessary to remove it in replacing the gage-glass.

Water-gage glasses 10 feet or more above the floor or firing platform may be protected by a guard similar to the above or by a shield of metal which can be rotated to the front of the glass to give temporary protection and then returned to position back of the glass, where it does not obstruct the view of the water-level.

Conditions must be such that the water-level in the gage-glass is distinct at all times. This object may be secured by the use of lights, or by marking on the shield back of the glass, such as 45 degree lines about one-quarter inch in width, spaced approximately one-half inch apart, with vertical center line in red.

ACIDS AND CHEMICALS

Case: Total loss of eyesight through acid blown in his face is the basis of an employer's liability suit brought by C—— M—— against the —— Chemical Works. The laborer was pouring the acid from one barrel into another, he states, when a fellow-workman opened a valve, admitting compressed air into one of the barrels. This blew the acid into M——'s face, burning his eyes, face, arms, and body.—*Elizabeth, New Jersey, Journal, April 18, 1916.*

There are many manufacturing operations which require the use of acids. In the manufacture of storage batteries, in soap making, in the aniline-dye industry, et al., large quantities of acids are constantly consumed. In processes calling for acid baths, bright dips, plating, et al., there is continuous use of dangerous acids and chemicals.

In approximately 75 per cent. of the industries studied in Buffalo there was apparent some process in which acids were present either as a product or as an element.

The risks are often most apparent where but small quantities of acids are used. For instance, a company may have need for not more than a single carboy's contents during an entire year. Little attention is paid to the storage of this carboy, and it is put away in some corner where it will be out of the way until needed. Sooner or later some of its contents are required, and a workman is sent to fill a pail or pitcher. In the attempt to pour the acid a slip occurs, the pitcher drops and breaks, spilling the fluid, or the unwieldy carboy overbalances and the same result occurs—with a badly burned workman having to be rushed to the company doctor and perhaps laid off for days.

Accidents of this kind are to be expected unless a pump has been furnished for removing the acid from carboy, or unless the container is securely fastened to an inclinator. An inclinator, even when but a single carboy is stocked, should always be provided. One man can safely handle a carboy held in such an inclinator as is shown in Fig. 31.

Recommendations: Adoption of safe methods of handling and transporting acids, and the use of protective goggles wherever there is any possibility of eye burns from splashes, or caustic chips, are the chief means of protecting workmen in this industry.

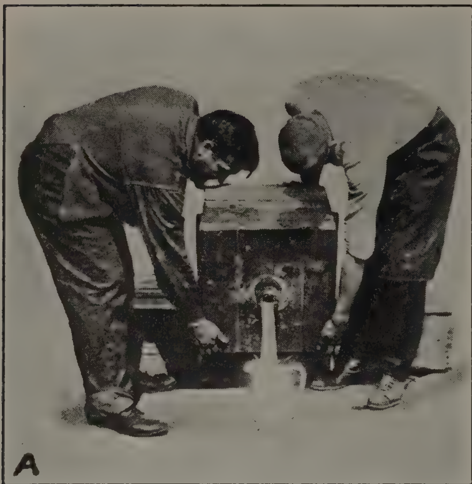

Fig. 30.—The handling of acids (*A*, Unsafe and inefficient method). Horace M. McCord & Co.

The transportation problem may be solved by the provision of the right type of carrier. Unfortunately, there still remains in common use the old-type carboy carrier, consisting of two sticks passed under the side cleats. To convey this apparatus requires the services of two men and is decidedly inefficient, expensive, and dangerous in comparison with other conveying methods.

Safe and economic practice requires the use of a carrier which can be safely handled by a single workman. In frequent use is the one-wheel carrier, which resembles in many ways the ordinary wheelbarrow, except that the carrying space of the latter is omitted. The handles spread outward and then are brought together to hold the boxed carboy firmly on an even and secure basis.

Fig. 31.—The handling of acids (*B*, Safe and efficient method). Horace M. McCord & Co.

The center of gravity of the load is thus very close to the

ground. This fact materially offsets the tendency of the single wheel carrier toward instability. However, in opening the handles to the necessary width there is the disadvantageous requirement for considerable space. This requisite often makes necessary the preliminary moving of carboys away from neighboring objects with which they have been stored before they can be loaded on the carrier, and so provides further opportunity for a mishap.

The General Chemical Company has designed and put into use an improvement on the one-wheel device. The chief change is that two wheels are provided, and, as is shown in Fig. 32, there is no requirement of side room. When picking up the carboy, the carrier is simply pushed forward with the cleats going under the side pieces on the carboy box. Although designed chiefly for 21-inch carboys, it is readily adjustable for those 18 inches in width.

Both of the types mentioned are adaptable for transportation of carboys over rough ground in yards as well as over smooth factory floors, although for inside factory use a low truck with small wheels and end rails is more frequently employed. Such a carrier should be small enough to fit into elevators. The lift required in loading is only a few inches, and thus the chances of spilling the acid are materially reduced.

The moving and pouring of acid should be the work, whenever possible, of one set of workmen who, made cognizant of the special hazards incident to such work, should be well trained in safety methods to offset them.

The methods employed in the filling of carboys and acid tank cars are extremely important from the standpoint of safety. The Buffalo plants studied had been singularly free from eye injuries so long as the work was performed in the regular location and the standard method used. However, it was sometimes necessary to fill carboys for a time at other than the usual places in the plant, and under unfamiliar conditions, injuries had been received from spattering acids. These were in large part attributed to the fact that the work was done in a temporary location, and under unaccustomed and perhaps adverse conditions.

Fig. 32.—One-man truck for 18-inch carboy, with detachable adjustment for handling lead carboys. A safe, light, smooth-running, and inexpensive carrier. General Chemical Company.

The essential in providing safe working conditions is opportunity for freedom of movement. No matter if all other conditions are safe, the lack of space will create a dangerous hazard.

An excellent apparatus for filling carboys has also been devised by the General Chemical Company. It consists of a lead pipe leading from the acid supply, with a quarter bend of about three and one-half feet. The stop-cock is installed near the end of this pipe, the few remaining inches being bent so as to fit into the neck of the carboy for several inches. When the carboy is filled, the pipe is lifted out and the carboy moved along the platform. In its normal position the end of the supply pipe is a few inches below the top of the carboy neck, and it requires a slight effort to spring the pipe into the neck. This holds the pipe firmly in place.

Another and more common method is to use a movable hose. Thus several rows of carboys can be filled without moving them. The bad feature of this method is in the deterioration of the hose, which, if allowed to progress until there is a break, may cause serious burns.

The development of satisfactory eye-protective devices for use in the chemical industry embodies features peculiar to that industry, and presents to the safety worker problems which as yet are but partially solved. Prominent among those who have made a special study of the subject is Mr. J. R. de la Torre Bueno, Editor of "The Bulletin," General Chemical Company, New York.

In a paper entitled "The Goggle Problem in the Chemical Industry," Mr. Bueno sums up the goggle requirements as follows:

"Many goggles have been made for chemical plants; some are still used. One type consists of a frame of soft rubber with a broad piece going across the nose and other pieces projecting beyond the temples. Another has hard-rubber cups fitted with pneumatic cushions along the edges to be inflated when worn by means of two little rubber tubes with stop-cocks. Both have the defect of heat; the soft-rubber ones have eyelets let in for ventilation, but in such a way that there is always danger of corrosive liquids flowing in. The hard-rubber contrivance is unpractical. Besides, the pneumatic binding readily gets out of order. The goggle most in vogue consists of a close-fitting flexible rubber half

mask or visor which adheres so closely to the face that liquids cannot seep under it and flow into the eye. This has a very great disadvantage, besides being unsightly—in the extreme discomfort produced in the wearer by reason of the heat and perspiration induced over the entire surface of the face with which it is in close contact.

"None of these types has efficiently solved the goggle problem in the chemical industry.

"Let me draw the ideal goggle: First, it has only one object, to protect perfectly the eye—that organ at once so delicate and so important to the worker. It is meant neither for comfort nor for beauty, but for safety. But in attaining its prime object, none of the collateral points should be ignored. These, then, are the objects to be attained, the marks of the ideal goggle, in the order of their importance:

Perfect protection to the eye.
Large field of vision.
Comfort.
Sightliness.

"Perfect protection can be secured by making the goggle of a material unaffected by chemicals and by making it fit so closely that neither above nor below nor at the sides may the least drop of a corrosive liquid penetrate to the eye, either by dashing against the goggle or by seeping under it. It must, therefore, be flexible in order to conform closely to the contour of the face.

"The large field of vision is a solved problem; it works against a deep eye-cup, which tends to increasingly limit the angle of sight with increasing depth.

"Comfort depends on two elements: the weight of the goggle and its ventilation, to prevent excessive perspiration. In the nature of things, as the chemical goggle is practically a half mask, its weight can be but little reduced, except by making it of aluminum and of light construction, two possible points of improvement. Excessive heat is overcome by ventilation and by reducing the surface in contact with the face.

"Sightliness is immaterial, given the necessity for perfect protection with a maximum of comfort.

"To meet the conditions set forth the goggle frame or mask should be of flexible wire netting; shaped to the face, but dished sufficiently to keep it from contact except along the edges, which should be bound with a soft, resilient rubber tubing. The edges should be made flexible, so that they may be bent to conform to facial contours, so as to avoid undue pressure at one spot or being

too far removed at another. The rubber setting for the large glasses should afford a wide range of vision and be perforated near the lenses to allow the escape of heated air, thus preventing condensation of moisture and clouding. The openings should be on the slant of the frame, so that in case acid flows down the face to the glass-settings, it will not readily leak into them; but if it does, they must be so close to the glass that any acid would flow down the inside of the lenses. The mask should be coated with a flexible, acid-proof varnish to make it impermeable and at the same time to preserve it from the corrosive action of the fumes about a chemical plant.

"This goggle would overcome three of the difficulties: it would give effective protection with maximum sight, together with a large degree of comfort. This is offered as an approximate solution of the goggle problem in the chemical industry."

THE TREATMENT OF ACID BURNS

Wherever workmen are handling acids or chemicals, there should be readily available clean running water to be used for washing hands or irrigating eyes, on which the chemicals may have splashed through accident or explosion. The best first-aid treatment in such an emergency is to lay the victim on his back and thoroughly irrigate the eyes, lifting the lids and enabling the water to reach as far thereunder as possible. A small flexible hose from which a moderate jet of water can be directed into the eyes should be at hand. If no better way is evident, plunge the head into a pail of water and open the eyes so as thoroughly to cleanse them of the acid. If the works are equipped with first-aid kits, then apply bichloride salve, bandage the eyes, and send for the doctor.

The important thing is to dilute the chemical as quickly and thoroughly as possible.

EYE BURNS FROM CAUSTIC SODA

In the manufacture of caustic soda, severe burns are likely to be sustained by the workmen unless constant care is exercised in preventing spattering of caustic soda liquor, and flying of chips of solid caustic soda when opening packages or when breaking up large pieces. The mucous membrane of the eyes and of the

mouth is particularly susceptible to injury from burns of this nature. While this hazard exists in the manufacture of *caustic* soda, attention is called to the fact that no special risks peculiar to themselves exist in the manufacture of either *soda-ash or bicarbonate of soda.*

Dilute acetic acid has been generally used for immediate first-aid treatment of burns from caustic soda. Its effect is to at once neutralize the caustic soda and convert it into harmless sodium acetate, stopping its injurious action upon the flesh or material attacked.

This treatment, as extensively used, "is prepared from good quality commercial acetic acid by diluting it to an exact content of 2 per cent. actual acetic acid. If the commercial acetic acid be of 30 per cent. strength, one quart of it is added to fourteen quarts of water to give 2 per cent. strength. After this dilution, the acid is analyzed to make sure that its strength is 2 per cent. After the eye is thoroughly washed with this preparation, sweet oil is applied. It is important that no absorbent cotton be used for cleansing the burn, because fibers of that cotton become embedded in the wound."*

Bottles containing the dilute acetic acid should be placed at frequent intervals throughout the manufacturing plant, and the workmen trained to use it immediately when needed.

Inasmuch as there are those who feel that dilute acetic acid wash does not measure up to the requirements for treatment of eye burns so successfully as might some other treatment, it should be stated that 1 to 2 per cent. solution of zinc sulphate as a relief measure has been in continuous use by at least one company† for the past eight years in hundreds of cases, regarding which its Safety Director writes: "We have yet to have a case of material loss of vision resulting from such an injury."

The primary reaction is as follows:

$$\underset{\text{Zinc sulphate}}{ZnSO_4} + \underset{\text{Sodium hydroxide}}{2NaOH} = \underset{\text{Sodium sulphate}}{Na_2SO_4} + \underset{\text{Zinc hydroxide}}{Zn(OH)_2}$$

* "The Hazards of Caustic Soda Manufacture and Use," E. Fiesinger, Semet-Solvay Company, Syracuse, New York.

† Hooker Electrochemical Company, Niagara Falls, New York, Mr. J. C. Slade, Safety Director.

The advantages which are claimed for the use of zinc sulphate over a dilute acetic acid wash are as follows:

(1) Less irritant.

(2) Complete or 100 per cent. reaction, rather than an equilibrium reaction as with acetic acid.

(3) Antiseptic quality of known value.

The details of the procedure adopted for the treatment of eye burns of this nature by the company referred to are as follows:

"We have distributed throughout our caustic buildings, distinctly marked, small boxes containing a 12-ounce bottle of 2 per cent. zinc sulphate solution and one or more eye-cups. These boxes are kept supplied with the solution.

"When a workman receives a splash of caustic in his eye, his first thought is to get the zinc sulphate solution, and we have trained them to keep the location of these boxes pretty well in mind. It is a fact, however, that some other workman, on hearing his cry, will get the solution to him. The eye is thoroughly washed at the point where the caustic is received, and then the man goes to the dispensary as quickly as he can get there. In the dispensary the man is laid out on the table and more zinc sulphate is applied. Of course, the pain is severe, so we then administer cocaine (2 per cent.), and after this repeat the dose of zinc sulphate. By this time we are pretty sure that the caustic is neutralized entirely, so we apply more cocaine, then olive oil, apply a cold compress, and send him to the physician. The after-care of such an eye-burn is exactly the same as for any burn or irritation of the eye, to permit of proper healing and control of possible adhesions. Ice-packs are kept on the eye while the pain is severe, and this usually makes a patient comfortable.

"Proper and quick neutralization is the essential treatment, and by quick neutralization I mean that received a few seconds after the caustic has entered the eye. Bad burns are the result of waiting until the patient can get to the dispensary.

"For acid burns we lay the same stress on proper and quick neutralization with sodium bicarbonate (c. p.), and follow this with the cocaine treatment and olive oil. For toluol and benzol splashes (where the result is not necessarily a burn, but intense irritation, and this is true with toluol fumes) our treatment is cocaine (2 per cent.) and let the patient stand with his eye open in front of a fan to evaporate the benzol or toluol. I refer particularly to toluol and chlortoluol, with its derivatives, as this is where the intense irritation is found. We also find that steam (properly regulated) is very effective for this purpose.

INDUSTRIAL POISONS

In Bulletin No. 100 of the United States Bureau of Labor, published in May, 1912, appears a translation in full of a list of industrial poisons cited by the International Association for Labor Legislation. A total of 56 poisons, exclusive of a few intermediates and by-products, appear in this list, and in addition to the designation of the poisonous substance, there are shown the branches of industry in which poisoning occurs, the mode of entrance into the body, and the symptoms of poisoning. To duplicate this list, which is available through the Government Printing Office, Washington, is needless. Of the 56 poisons, 36 have more or less serious effects upon the eye.

The most common results are irritation of the mucous membranes, causing lachrymation and light flashes before the eyes. Other results may be the discoloration of the conjunctiva, disturbance of the sense of vision, retrobulbar neuritis, choroiditis, dilatation of pupils, photophobia, clouding of the cornea, diplopia from paralysis of the muscles of the eyes, amblyopia, protrusion of the eyes, contraction of pupils, ulceration of orbital bones, shrinking of the eyeballs, erosion of the cornea, transient blindness, progressive atrophy of the optic nerve, and permanent blindness. Resulting from certain of these industrial poisons may come a combination of two or more of the above symptoms, and these, it must be understood, are usually but concomitant with other, and frequently serious, affections of the body.

The mode of entrance of these poisons into the body is most frequently in the form of vapor, through the respiratory organs. The inhalation of dust may likewise produce the effect through the lungs. Direct action of the poison through or on the skin is another method of entry, while occasionally the poison is carried into the body through the digestive tract, due to handling of food-stuffs, cigars, cigarettes, chewing tobacco, etc., with hands from which the toxic substance has not been thoroughly cleansed.

Of special note as productive of serious symptoms and results are ammonia, benzol, and the other intermediates of the dye industry, brass, carbon disulphide, dimethyl sulphate, hydrofluoric

acid, lead, methyl alcohol (see section devoted to that subject, pp. 92–99), methyl bromide, nitroglycerin, and phosphorus.

The measures of relief for the symptoms excited by the poisons are given in the Bulletin referred to, as are also instructions for the protection of industrial workers exposed to the toxic material covered. Adoption of the following recommendations as given therein will greatly reduce the dangers from these toxic materials:

MEASURES FOR THE PROTECTION OF INDUSTRIAL WORKERS AGAINST THE DANGERS OF POISON

1. Properly adapted buildings, thick walls of separation for dangerous rooms, good lighting, facilities for keeping the workshops clean and for effective ventilation.

2. Apparatus adapted to its special purpose, whenever possible, closing tight in every part.

3. Appliances for accomplishing the arrest of gases and dust at their place of origin, their removal, by exhaust fans, and in a suitable manner rendering them innocuous or collecting them, thus preventing them from entering the nose and mouth.

4. So far as possible avoidance of direct contact with poisonous materials or substances injurious to health in working with, transporting, or packing them.

5. The displacement of particularly dangerous labor methods and materials by the introduction of less dangerous labor processes and materials, as well as by the employment of materials satisfactorily pure chemically.

6. Instruction of workmen just entering upon an occupation concerning the properties of the poisonous substance extracted, manufactured, used, or otherwise evolved, and, whenever possible, cautionary leaflets should be put into the hands of the workers.

7. The repetition of this instruction at frequent intervals.

8. Posting of precautionary regulations and warning placards containing admonitions for the exercise of special caution, and enjoining the observance of measures for insuring safety. Constant supervision of all dangerous employments by expert and responsible persons.

9. Employment of appropriate means for personal protection, as work clothes, caps, gloves, goggles, and, as necessary adjuncts, mouth and nose shields, respiratory masks, and the like, in case the appliances named in rule 3 are inapplicable.

10. Practice of bodily cleanliness by the use of wash, bath, and dressing rooms, the use of special rooms for eating, separate wardrobes for street and work clothes, and frequent, non-hazardous cleansing of the clothing.

11. Immediate report of symptoms of indisposition, attention to wounds of the skin caused by the handling of corrosive materials, the speediest employment of an unexceptionable antidote giving promise of success at the very first symptoms of poisoning, with the simultaneous summoning of the physician.

12. The installation of a healthy working force capable of withstanding exposure to the poisons. Temporary or permanent exclusion of sick workmen from the dangerous departments of the industry. Medical examination of the workers in dangerous employments at suitable intervals. Under certain circumstances there should be a change of work in occupations giving rise to chronic poisoning.

13. The utmost possible reduction of the hours of labor in dangerous employments.

REMOVAL OF DANGEROUS FUMES, VAPORS, AND GASES

Recommendations covering the technical points involved in the proper installation of hoods and exhaust systems are so easily available that only the general requirements will be touched upon in this section. For those seeking an intensive treatment of the subject there is recommended a study of Bulletin No. 82, of the Department of Labor, State of New York, from which publication many of the statements and recommendations given in the following paragraphs are drafted.

In the section devoted to sand-blasting (p. 34) attention is directed to the removal of dust by means of a *downward* air-draft. While such a system may obtain to advantage where it is desired to remove stone or wood dust or heavy gases, for the

removal of such fumes and vapors as exist in most manufacturing operations it is the *upward* air-draft that is employed. If it is not practicable to employ either downward or upward air-currents, a lateral system may be used.

Light vapors and gases which have a temperature higher than the outside air will rise through a pipe or chimney without necessitating the provision of a forced draft. It is, however, usually

Fig. 33.—Ventilating System for Removing Acid Fumes. The suction opening is below the operator's breathing line, and no fumes reach his face. American Museum of Safety.

found advisable to install hoods and create artificial currents which will dispose of the fumes and vapors as closely as possible to their source and immediately upon their emanation. Poisonous fumes may otherwise escape into the general atmosphere during the time before the acid or other substance from which they are arising has been sufficiently heated to create the natural draft.

If it is difficult to secure a continuous upward air-current, it will be usually found that the trouble is due to the situation of the chimney being such that the wind pressure deflected downward into it is greater than the circulating pressure within the chimney. Such a condition is often found where a chimney is located near a wall or building which is higher than the stack. The remedy is to raise the outlet above the obstruction to the wind, thus removing the impediment which has caused the downward deflection.

The double hood has been recognized as especially efficient in removing vapors and gases. In its construction there is a "clearance of one inch between the inner and the outer walls at the edges, at which there should be a minimum velocity of air at not less than 1000 feet per minute, and 200 feet per minute over the central area of the hood.

"The mouth of the hood should extend over the furnace, vat, or machine at least six inches in every direction, if the hood is elevated not more than two feet. For every additional two feet of elevation such hoods must be increased six inches in all directions. The farther away from the vat, the less effective the hood will be. The outer wall should be extended an inch or two downward below the inner shell, which makes it more effective in catching rising fumes than it would be if both walls were of the same length. The opening at the apex of the hood, together with the area at the base between the inner and outer wall, should equal the area of the pipe or branch pipe from the top of the hood. A still further advantage of the double hood is that air-currents from windows and doors do not affect the upward movement of air in these hoods as readily as in the single type. The diameter of the pipe leading from the apex of the hood should be approximately one-third the area of the surface from which the fumes arise."

SPRAY PROCESS HAZARDS

The spray process of applying the finish on a multitude of articles—from toys to passenger coaches—has within recent years almost entirely superseded former methods of application by hand-brush or dipping. Colors, fillings, shellacs, lacquers, varnishes,

et cetera, and metallic coatings as well, of aluminum, copper, lead, nickel, tin, and zinc, are now generally "sprayed" on by means of compressed air.

In order to make possible the spray application of coatings of the kind mentioned, they must be in a fluid state in order to facilitate the even spreading of the finish. From certain of the solvents employed there are fumes and gases against which protection must be provided. In another section (p. 92) wood alcohol has been mentioned as a frequently used solvent for shellacs and varnishes, and the fumes of this as well as of other solvents and driers must be eliminated to make the spray process safe for the operator.

Fig. 34.—Applying a finish by the spray process, showing hood and exhaust for removal of noxious fumes. American Museum of Safety.

In regard to protection from fumes and vapors arising in the use of the spray process for coating small articles, the following recommendation appears in Bulletin No. 82 of the New York State Department of Labor, from which quotation has previously been made:

"Such work should be performed with an inclosed hood varying in size according to the size of the article to be coated. The conical portion of the hood should be in the direction of the flow from the spray brush, with a pipe leading from it of an area not less than one-sixteenth of the cross-sectional area of the hood, with a minimum air velocity of 5800 feet per minute, corresponding to two inches static suction. It is wise, when providing a fan in the pipe, to place it at

a point as remote from the hood as possible, or arrange to readily detach the fan, in order to clean it of material which attaches itself to the blades."

Primarily, the operators should be warned of the dangers incident to the particular spraying process in which they are engaged. The maintenance of the exhaust system employed should be carefully watched to see that exhaust pipes are not clogged with paint, varnish, shellac, or other materials sprayed.

"Cabinets should not be straight along the back and top, but should be curved so as to form a sort of cone or funnel, shaped so that a uniform draft may be had at all times and in all places. Cabinets that have a good draft are often too shallow, so that the spray rolls out and envelops the operator before it can be drawn away by the exhaust system. Operators should be taught how to use the spray so that the fumes from it will be kept inside the hood or cabinet, so far as possible. If, for example, the pistol is held so that the spray strikes the work at right angles, the vapors from it are almost sure to envelop the operator, and at such a time he can hardly avoid inhaling them."*

The article above referred to also advises against the employment of any person who is near-sighted for such work as this. It is a valuable suggestion, as the matter of a few inches will remove one from the area of poisonous vapor, and the near-sighted operator must, of course, bend closer toward his work than will one with normal vision. The same argument applies forcibly to the provision of good lighting. Daylight or artificial light should be completely adequate for accomplishing all parts of the spraying without straining in watching the application of coating.

METHYL ALCOHOL (WOOD ALCOHOL)

Case: A—— D—— was blinded from inhaling the fumes of Columbian Spirits (a trade name for purified wood alcohol) which it was alleged by the victim had been used as a solvent for shellac which he was using in painting the interior of beer vats at a brewery. He brought suit for damages, the case coming to trial in the Supreme Court, New York City. The jury awarded the plain-

* "The Travelers' Standard," September, 1917.

tiff $25,000 damages. This verdict was set aside by the presiding judge. The case has been appealed and is still in the courts.

The foregoing is but one of many cases of impaired vision, blindness, and death resulting from the use of methyl (wood) alcohol. In fact, one investigator has recorded more than 1000 casualties which have occurred during the past twenty years due to the use of this poison.*

The harmful physiologic action of wood alcohol may be induced by breathing its fumes, by taking it internally, or by absorption through the mucous membranes of the body. Its effect is usually noticeable very shortly after exposure, though this does not necessarily follow. It usually acts as an acute poison. As before stated, vision may become impaired, total blindness occur, or death itself result. It appears, however, that there are some persons who are practically immune to any toxic effect from this poison.

The wood alcohol used in the United States is obtained chiefly from the destructive distillation of wood—hard wood, birch, beech, maple, oak, elm, and alder being best for the purpose. A most lucid description of the process of distillation may be found in the report of Charles Baskerville, Ph.D., F.C.S., appearing as Appendix Six of the Second Report of the New York State Factory Investigating Commission, submitted to the Legislature January 15, 1913. After distillation, refinement, et cetera, the final product thus obtained is commercial wood alcohol, usually sold at 95 per cent. strength by Tralles' Alcoholometer. It contains from 10 per cent. to 20 per cent. acetone and varying proportions of other organic impurities.

The chief uses to which it is put are for the denaturing of ethyl or grain alcohol; for various purposes in lines of common manufacture; as an ingredient in medical and pharmaceutical preparations; in the chemical industries and as a fuel and illuminant.

In 1906, Congress, following the lead of European countries, enacted a law permitting the general use of a tax-free industrial

* "Wood Alcohol. A Report on the Chemistry, Technology and Pharmacology of and the Legislation Pertaining to Methyl Alcohol," Charles Baskerville, Ph.D., F.C.S.

domestic alcohol in order to stimulate industrial purposes for which the high cost of grain alcohol was prohibitive. Denaturalization is required at the source of manufacture by the addition of certain substances which destroy the suitability of the ethyl alcohol for purposes other than those which the passage of the law was intended to benefit. Of the various denaturing agents, wood alcohol is chief. In the Federal law it is specified that the

Fig. 35.—Wood vats. Varnishers must be supplied with artificial ventilating apparatus.

denaturalization of the ethyl alcohol shall occur "in the presence and under the direction of an authorized government officer, with methyl alcohol or other denaturing material or materials or admixtures of the same which will destroy its character as a beverage and render it unfit for liquid medicinal purposes."

In the arts and crafts wood alcohol is used in the making of hats, artificial flowers, incandescent mantles, et cetera. It is an

excellent solvent for shellacs, varnishes, and finishes used in the manufacture of pencils, rattan goods, toys, passenger coaches, carriages, furniture, pianos, organs, picture molding, and most recently in the manufacture of aëroplanes.

As a solvent for lacquers and enamels wood alcohol appears in the manufacture of brass beds, hardware, lighting fixtures, patent leather shoes, leather clothing, et cetera.

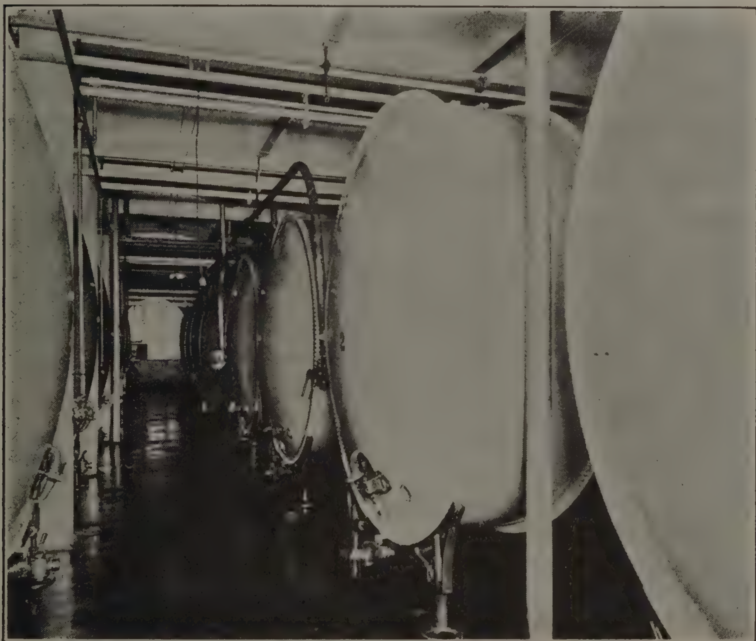

Fig. 36.—Glass-lined steel vats, which do not require varnishing.

In the chemical industries it is used primarily as a solvent for fats, volatile oils, camphor, resins, gums, varnishes, stains, shellacs, alkalis, and various salts, and in the manufacture of celluloid, et cetera. In substances like that last mentioned the alcohol does not remain as a hazard in the finished product, and is therefore dangerous only as it may be used in the process of manufacturing, whereas in varnishes and shellacs the wood alcohol remains

as such and may prove deleterious either through the inhalation of its fumes or through its being drawn off from the varnish and drunk, as is occasionally done by those ignorant of the danger.

In the chemical industries it is likewise used as an extractive—in the manufacture of smokeless powder, fulminate of mercury, and other explosives, and as a reagent for the detection of salicylic acid, the determination of boric acid, the preparation of grape-sugar, and as a substitute for ethyl alcohol for other purposes.

In pharmaceutic and medicinal preparations it is also used as an extractive, it being said to give a better yield than ethyl alcohol for many substances, such as belladonna, nux vomica, jalap, resin, et cetera. It is substituted for ethyl alcohol in washes, tinctures, liniments, patent medicines, extracts, and essences, such as Jamaica ginger, lemon extract, witch-hazel, bay-rum, numerous cosmetic preparations. In the preparation of synthetic drugs it appears in the making of artificial oil of wintergreen, gallicin, methylal, methylene-blue, methylene chloride, et al.

Wood alcohol is likewise used to very considerable extent as fuel, to some extent as an illuminant, and as a cleaning fluid.

For many of the uses cited in the foregoing, denatured alcohol serves every purpose of wood alcohol.

In normal times the denatured product is as cheap as wood alcohol,—occasionally cheaper,—and has none of the dangers attendant upon the use of the latter.

There are certain purposes for which the use of wood alcohol appears to be necessary. Wherever such is the case, its use should be most carefully guarded in order to conserve the vision, health, and lives of those who may be exposed to its poisonous qualities.

So far as the general public is concerned—those who are not engaged in occupations in which wood alcohol must be used—the chief danger lies in the unrestricted sale of this poison, a liberty which thus makes it possible for unscrupulous dealers to substitute it for grain alcohol in the preparation of medicines, liquors, essences, cosmetics, et cetera, as have been mentioned.

It has been but a few months since an artisan of New York was blinded by drinking a cordial which to all appearances was a

genuine Italian liquor, but which, following the catastrophe which befell the victim, was found to have been spuriously manufactured in this country, and upon analysis showed nearly 50 per cent. wood alcohol. In the knowledge that but one teaspoonful of this poison taken internally may cause blindness, it is evident how great a danger there is in permitting its unrestricted sale and use.

In spite of the educational and legislative campaign which has been carried on for the protection of the public during recent years, wood alcohol is still being manufactured and sold under misleading trade names, among which are Columbian Spirits, Essence Niobe, Peau d'Espagne, and Colonial Spirits, which in themselves or in their abbreviations may prove misleading not only to the ignorant, but also to those who know the poisonous quality of methyl alcohol—for the deodorized, purified product is extremely difficult to distinguish from grain alcohol. Blindness or death has resulted in many cases among those who, being unable to purchase intoxicating liquors, have drunk Jamaica ginger, lemon extract, or patent medicines in which wood alcohol has been used.

Investigation by health boards and individuals specially interested has disclosed the fact that it has not been an infrequent procedure for barbers to use wood alcohol instead of grain alcohol in making up cosmetic preparations, bay-rum, and witch-hazel. In New York city the Sanitary Code now requires* that

* The following amendment to the New York City Sanitary Code was adopted by the Department of Health July 28, 1914, to take effect September 1, 1914:

Section 66A. No person shall sell, offer for sale, deal in or supply, or have in his possession with intent to sell, offer for sale, give away, deal in or supply any article of food or drink, or any medicinal or toilet preparation, intended for human use internally or externally, which contains any wood naphtha, otherwise known as wood alcohol, or methyl alcohol, either crude or refined, under or by whatever name or trade mark the same may be called or known, unless the container in which the same is sold, offered for sale, given away, dealt in or supplied, shall bear a notice containing the following device and words conspicuously printed or stencilled thereon, viz.:

SKULL AND CROSSBONES — POISON — SKULL AND CROSSBONES

WOOD NAPHTHA
OR WOOD ALCOHOL

WARNING—It is unlawful to use this fluid in any article of food, beverage, or medicinal or toilet preparation for human use internally or externally

the label on any container in which wood alcohol is sold shall plainly indicate the contents, and that the conventional poison label shall likewise be prominently displayed thereon.

The New York City Department of Health during the year 1914 instituted proceedings against 85 barbers and dealers in barbers' supplies who were detected using wood alcohol instead of grain alcohol. These cases were tried in the Court of Special Sessions, and sentence imposed as follows:

Jail sentences	1 (thirty days)
Fines	26
Sentences suspended	51
Cases discharged	7

A total of $1095 in fines was imposed, the largest of these being for $250.

Recommendations: Wood alcohol, or any fluid containing wood alcohol, should be labeled on its container as a poison, with the warning plainly displayed to the effect that, taken internally, it may cause blindness or death. The usual poison designation—the skull and cross-bones—should appear prominently. Inclusion of a further warning that the fumes of wood alcohol inhaled in an insufficiently ventilated place are likewise injurious to eyesight is an advisable precautionary measure which has already been adopted in Montana.

The use of wood alcohol in any food, condiment, flavoring extract, or liquid capable of being used in whole or in part as a beverage or as a medicine should be prohibited by law.

In order to protect workers who might be exposed to its fumes, exhaust systems should obtain wherever needed, and legislation or regulations enforced which would require that ventilation by artificial means where necessary be provided in such operations as the varnishing of inclosed vats, where the workers are particularly exposed to the poisonous fumes. In the varnish rooms of furniture factories and the like, where these fumes may be constant, ample ventilation should be provided, the standards of same to be determined in each case by the Board of Health, or such board, with authority, as may be designated. Many breweries now use glass-lined vats, thus eliminating the necessity of varnishing.

Where workmen are forced to dip their hands and arms into substances of which wood alcohol is an ingredient, they should be provided with arm coverings impervious to the effect of the liquid.

Baskerville emphasizes the need for a clearer understanding of the fact that in certain processes in which wood alcohol is employed it becomes a constituent part of the final product, and is not thereafter a hazard. In all processes in which it remains as wood alcohol, the dangers attendant upon its use should be most carefully guarded against.

BOTTLING ACCIDENTS

Workers engaged in bottling aërated liquids are subject to injuries from bottle breakage. Bartenders and soda-fountain tenders have been injured occasionally by flying corks and by pieces of glass from bottles which have unexpectedly broken as a result of gaseous pressure during the bottling, wiring or capping process.

The number of bottles that burst is very considerable, and it is rather remarkable to note that new bottles and siphons are more apt to break than are old ones. Siphons burst less frequently, but the explosion and danger are greater. The use of goggles, and a wire screening, or other substantial guard, placed between the danger point and the workman, will provide the necessary protection.

MINING AND QUARRYING

Case: MINER'S EYES BLOWN OUT BY AN EXPLOSION. A—— Y,—— a Russian, aged thirty-two years, having a wife and two children, residing at F——, lost the sight of both eyes in a dynamite explosion which occurred yesterday morning. Y—— had prepared a blast of several dynamite sticks and ignited the same. When there was no discharge he went back to investigate, as many an ill-fated workman has done, despite warning and mandates of mine laws. He had just reached the place when a terrific explosion took place, blowing out his eyes and studding his face with powder and shot wounds.—*Shamokin, Pennsylvania, Dispatch, April 28, 1916.*

In blasting operations, in mining and quarrying, or in excavating for the foundations of new buildings, street repairs,

etc., workmen are frequently injured by premature explosions occurring at times in the preparation of the charge, due to careless handling when using electric firing devices through touching electric wires and in other cases through careless handling of the detonators or blasting caps. The use of too short fuses likewise is a prominent factor in the occurrence of premature explosions.

As in the case cited, misfires are also the cause of many serious accidents. Misfires or individual failures are more likely to occur with fuse than with electric shot firing. Unfortunately, where there are a very large number of shots to be fired at one time, the miners prefer to use the fuse, although electricity is far safer. Their preference is doubtless due to the fact that in connecting up a large number of shots electrically it requires great care to see that the circuits are complete.

With the use of the fuse, shots can be arranged to go off in a certain rotation. Sometimes, however, a near-shot may cut off the fuse of another and in this way there results an unexploded charge.

The condition of sometimes having cartridges in the "muck" or broken rock is not uncommon, and the only way to prevent trouble is to clean up very carefully where it is suspected that one of the shots has not gone off. In electric firing this is difficult to determine—and sometimes is with fuses if many shots are being fired at short intervals.

Misfires have been known to "hang fire" for two or more hours, and because of that fact excessive precautions should be taken if the least doubt exists as to the firing of all shots—miners to delay half an hour, or better—several hours, before going back.

The following method of handling hang-fires has been suggested to the author by Mr. S. P. Howell, Explosives Engineer, Bureau of Mines, Experiment Station, Pittsburgh, Pa. It is one which has not as yet been officially adopted by the Bureau, but is presented on its merits:

Where a shot is encountered that has misfired, it should not be approached even for the purpose of inspection until thirty minutes have elapsed if squibs were used; three hours if fuse were used, and ten minutes if electric detonators or electric igniters were used, and preferably longer, lest the trouble be a hang-fire and not a misfire.

The first inspection of a shot that has misfired should be to determine whether or not the cause be outside of the drill hole. It may be that the squib has not left the mouth of the drill hole, that the fuse has not burned to the mouth of the drill hole, or that the leg of the electric devices (electric detonators or electric igniters) or the leading wire is short-circuited or open-circuited outside the drill hole, or that the blasting machine did not provide adequate current. If the cause lies outside of the drill hole, it may be remedied without disturbing the charge. Where a misfire has occurred in a hole containing electric devices, the blasting machine should be promptly disconnected and removed.

If it is definitely established that the trouble is within the drill hole, then it is in general recommended that another hole should be drilled near enough to the first charge so that a charge in the second hole will explode or expose the first charge, and far enough from the first charge so that there is no chance of the drill striking the charge. Where practicable the holes should be parallel. For short holes (six feet or less) the separating distance should be 18 inches, and, if possible, two feet or slightly more. For deeper holes the separating distance should be correspondingly greater.

Where all or a portion of the first charge is not exploded, careful search should be made for it, and such search should be made without tools. Special effort should be made to recover the detonator or electric detonator, if either were used in the first charge. It is recommended that before firing the second charge the fuse used with the detonator, or the legs of the electric detonator, in the first hole be anchored, with wire or strong cord, outside the drill hole so that if unexploded they may be recovered more readily.

In certain special cases that obtain it is desirable that an alternate method be proposed for use if approved by a responsible official. It should always be remembered that there is a risk incident to the disturbing of any charge.

In the case of a **black blasting powder charged to be fired with a squib,** when it has misfired there is nothing to prevent trying another squib on it after at least one hour has elapsed, or another squib after an additional hour or more has elapsed, etc. If this fails, the stemming may be carefully withdrawn with a copper scraper and water turned into the hole to wet the powder before it is taken out. The scrapings, including the stemming, should be placed in a closed receptacle, taken to the surface, and rendered immune by throwing it in running water. After drying out, the hole may be recharged.

High Explosives in Metal Mines—No Stemming Used in the Hole.—In the case of these charges, if the primer be nearest the mouth of the drill hole, attempt may be made to substitute a new for the old primer after the latter has been carefully removed, or in cases where electric detonators have been used a new primer may be added without withdrawing the old one. Where insensitive explosives, such as gelatin dynamite, are used, the new primer should preferably be a high-grade straight nitroglycerin dynamite.

Very careful consideration to shot firing, among other things with reference to explosives, is given in the revised Mining Code for New York. Relative to the prevention of premature shot firing, and the recognition of misfires, paragraphs 20 and 21 read as follows:

"All power lines and electric light wires shall be disconnected at a point outside the blasting switch before explosives are taken in and leading of holes is proceeded with. No current by grounding of power or lighting wires or bonded rails shall be allowed beyond blasting switch after explosives are taken in preparatory to blasting, and under no circumstances shall grounded current be used for exploding blasts."

"When a blaster fires a round of holes, he shall count the number of shots exploding, except in case of instantaneous blasting by electricity. If there are any reports missing, he shall report the same to the gang boss or foreman. If a missed hole has not been fired at the end of a shift, that fact, together with the position of the hole, shall be reported by the mine foreman or shift boss to the mine foreman or shift boss in charge of the next relay of miners before work is commenced by them. The blaster shall not leave until he has placed a wooden plug painted red in the mouth of the missed hole, if possible."

Data on this entire subject and instructions covering correct methods of firing blasts by electricity are so readily available* that only brief comment thereon will be made herein.

Where there are but a few shots to be fired in a circuit, the

* "A Primer on Explosives for Metal Miners and Quarrymen," Bulletin No. 80, Bureau of Mines, and "A Primer on Explosives for Coal Miners," Bulletin No. 17, with a most comprehensive list of other publications on mine accidents and tests of explosives are temporarily available for free distribution, and interested persons may secure the same by addressing the Director, Bureau of Mines, Washington, D. C.

miner who is to act as shot firer may find it possible to use a light, portable firing machine which he can carry about until ready to use, thus insuring against premature firing by any other person. Such small devices, however, can at best be used only for light blasts.

Machines for the firing of a large series should be tested at frequent intervals to ascertain whether they are being overloaded. Batteries of insufficient strength for firing heavy blasts, or large series, are often responsible for the occurrence of misfires.

Leakage from the electric main to the earth and then through the leading wires and connections, which may have become bared through rough handling, or as the result of improper insulation, may provide an unexpected current which will cause a premature blast.

Regarding explosions from stray currents, Mr. S. P. Howell, hitherto referred to, makes the following recommendation:

"Where there is any evidence of stray currents, a precautionary measure against the danger therefrom is to twist the ends of the legs of the electric detonator or of the electric igniter together. This is a very effective way of preventing a current from passing through the bridge of these devices by short-circuiting them. Care should be taken, however, in connecting up the leading wires to the legs, to be sure that the legs are separated."

For the final testing of the firing line, in order to show that the circuit is complete and that there is no leakage in the wires,*

"a special galvanometer may be used, together with a battery such as many of the manufacturers of explosives now sell. This galvanometer, like others, bears on its face a needle, which is turned or deflected when an electric current is present in the system. By noting whether this needle is or is not deflected one can tell whether the circuit is open or closed, and the extent of the deflection shows just what resistance there is in the circuit. To use the galvanometer, the wires leading from it are connected to the two binding posts of the firing machine to which the wires leading to the charge have already been connected, and the deflection is then noted. The current generated by the weak battery cell attached to the galvanometer should not be strong enough to fire the electric detonator used in the bore holes, but should be strong enough to deflect the galvanometer needle."

* "A Primer on Explosives for Metal Miners and Quarrymen," pp. 52, 53.

"The testing galvanometer, with its attached battery, should never be applied directly to the face to be blasted, even when it is being used to find out which of the electric igniters or electric detonators are defective, after the test has shown no current. The tests for the separate detonators or igniters should always be made through leading wires sufficiently long to allow the person making the tests to stand where he will be perfectly safe in case the blast should be fired, and on no account should this testing of the igniters or detonators be made while any person is so near that he may be in danger from the blast."

Fig. 37.—Crimping detonator on fuse. United States Bureau of Mines.

In the handling of explosives by miners and quarrymen, there is always the hazard from carelessness or recklessness on the part of the individual. Perhaps in no single operation is this more evident than in crimping blasting caps onto fuses. Electric detonators do not require crimping, as the lead wires are already inserted in the detonator. They are, because of the nature of their explosive content, extremely sensitive to heat, friction or blows, and are extremely violent in their explosion. The methods of accident prevention from this source are summed up as follows in "A Primer on Explosives for Metal Miners and Quarrymen":

"These devices should be treated with the utmost respect.

"Never attempt to pick out any of the composition.

"Do not drop them or strike them violently against any hard body.

"Do not lay them on the ground where they may be stepped on.

"In crimping, take the greatest care not to squeeze the composition, and never crimp with the teeth, for there is enough composition in one of these small capsules to blow a man's head open."

That the warning contained in the preceding paragraph is not a needless one is evidenced by the known accidents that have resulted from just such careless procedure. One safety engineer has recently brought to the author's attention a case where a man's entire face and jaws were blown off by the explosion of a cap that he was crimping around the fuse with his teeth.

Crimpers of various types are always available, and their use not only provides for a more efficient sealing of the detonator, but is the only safe practice for this operation.

GOGGLES FOR QUARRYMEN

In many quarries visited by the author it has been noted that the men who are engaged in chipping, either in the open cuts or in the works, are not equipped with protective goggles, and as a consequence thereof there are many abrasive and penetrative wounds of the eyes constantly occurring. In one of the great quarry centers in Minnesota it was found that practically none of the operators had provided goggles for their employes. Many of the chippers had for their own protection purchased cheap goggles, which were found to be made of glass of insufficient strength to resist the blow inflicted by even a small chip. Moreover, there was no protection afforded by wire screens on the sides of goggles, and in none of the works were protective standing screens in evidence.

The same recommendations as obtain in the section on Chipping Operations, pages 21 to 24, are correct for the elimination of these hazards in stone works.

MINER'S NYSTAGMUS

Coal-miners frequently work for long periods in a sitting or recumbent position, which requires the eyes to be turned upward and obliquely, thus causing considerable strain and exhaustion of the ocular muscles. As a result, there occasionally develops a condition called "miner's nystagmus," characterized by continual short, rapid involuntary movements of the eyeball, which are chiefly rotary. The rapidity of the ocular motions varies greatly—from 60 to 150 per minute, and as many as 350 motions per minute having been recorded by certain observers.* The author has seen no definite statement as to the percentage of miners thus afflicted in the United States, although it is believed that the occurrence of this trouble is not so frequent as in the British Isles, where Snell reported approximately 5 per cent. of miners as having nystagmus. A much higher estimate (20 per cent.) is given by Romieé in writing of conditions in Belgium some years ago.

The patient so afflicted will complain of objects dancing before his eyes, headache, and other symptoms, all of which will clear up rapidly if a change of work is made. "After relief has been effected return to the mine is practicable, provided the head can be kept straight and the upward turn of the eyes avoided. Resumption of the old kind of work is followed, sooner or later, by a recurrence of the symptoms. Medical treatment is also of service."*

AGRICULTURAL HAZARDS

Case: A—— B—— lived on a plantation 16 miles out from New Orleans, was stretching a line of barbed wire, when a staple flew out and inflicted an ugly cut in his right eye. He let the injury go for several days, but finally went to the Eye, Ear, Nose and Throat Hospital of New Orleans. Careful treatment over a long period healed the wound, although his sight in that eye is permanently impared because he did not go to the hospital soon enough.

Case: Ben Britzius, of Pierre, a young farmer of Hughes County, was brought to Aberdeen and his left eye was removed as the result of an accident while shredding corn on his farm. It appears that the belt slipped from the machine,

* Dangerous Trades (A Compilation of Articles on the Subject, by Thomas Oliver), Chapter LVIII (Simeon Snell).

hurling a wire staple into the man's eye, lacerating the eyeball beyond any chance of saving it.—*Sioux Falls, S. D., Press, December 8, 1915.*

Case: As the result of an accident several days ago Richard Lowry, a prominent young man of Webster County, Saturday afternoon suffered the removal of his left eye at the Americus Hospital. Mr. Lowry, it seems, was repairing a broken plow when a piece of steel, filed off the plow-hoe, lodged in his left eye. He came to Americus immediately and underwent a careful diagnosis. It was found, after the examination, that removal was necessary.—*Americus, Georgia, Recorder, January 30, 1916.*

It is a far cry from the industrial hazards to eyesight in the machine shop, the foundry, or the laboratory, to those which are found in agricultural pursuits. In a Conservation of Vision pamphlet of the American Medical Association entitled "Industrial and Household Accidents to the Eyes," prepared by Dr. Harold Gifford, Omaha, Nebraska, it is stated that in all but the large manufacturing centers the majority of serious eye accidents occur among agricultural laborers. Statistics certainly indicate that such accidents are occurring in great number. Most of them might have been avoided by care. Many of them have resulted in infection and blindness because, as in the first case cited, days or weeks were allowed to intervene between the time when the injury was sustained and the date of calling in an oculist or physician. Distance from town, ignorance of the serious nature of the wound, dependence upon proprietary remedies, and various other reasons are given for these fatal delays.

The hammering of farm machinery, home-made repairing, and the like, flying staples from handling of barbed-wire fencing, injuries from baling wire, hooks, etc., head the list of causes responsible for these accidents. Then come what Dr. Gifford terms the "Botanical Injuries," of which the typical ones are superficial but ragged wounds of the cornea from blades of corn or beards of wheat. Wood-chopping injuries are common—not only to the chopper, but to the bystander as well. Horning from cows and kicks from farm animals swell the list, and, finally, "the eye is frequently injured by side swipes from switching tails." It is interesting to note in this connection that kicks from *cattle* rarely injure the eye on account of the limited vertical displacement of their hoofs.

Unfortunately, in but few of the reports of State Labor Departments, Insurance Commissions, et al., are there found any data of importance relative to the occurrence of accidents in agricultural industries.

In California, however, of the 1264 permanent injuries reported in 1913, 123 were agricultural. Of 65,741 temporary injuries reported in 1915, 3249 were agricultural. As an indication of the subindustry or particular occupation in which the injury occurred, the following statistics from the California report are of interest:

3249 TEMPORARY INJURIES OCCURRING IN AGRICULTURE GROUP OF SUBINDUSTRY. TIME: 12 MONTHS—JANUARY 1 TO DECEMBER 31, 1915

AGRICULTURE

General farming (no blasting), horticulture, viticulture, hop culture, and conservative forestry	2189
Dairy farming	197
Power farming (machinery, power driven, no blasting)	21
Stock farming (poultry ranches)	420
Garden or truck farming, floriculture, nurseries, and landscape gardening	45
Operating farm machinery—not by farmer—all sorts of threshing, hay baling, etc., where work is sublet	79
Picking, packing, drying, and curing of fruits	252
Farm work where explosives are used	7
Fumigating and spraying fruits	39
Total	3249

Note.—Irrigation plants operated by regular farm laborers fall under the head of "General Farming." All reclamation and irrigation projects operated by a class of labor which never engages in farm work, but follows the construction camp from one district to another, fall under the classification of "Construction."

3249 TEMPORARY INJURIES OCCURRING IN AGRICULTURE TIME: 12 MONTHS—JANUARY 1 TO DECEMBER 31, 1915

Chief Causes

Machinery	296
Dangerous substances	423
Falling, rolling, or flying objects	242
Personal falls	378
General or all other causes	1696
Unknown	214
Total	3249

3249 TEMPORARY INJURIES OCCURRING IN AGRICULTURE
TIME: 12 MONTHS—JANUARY 1 TO DECEMBER 31, 1915

Time Lost in Days by Chief Causes

Machinery	5,395
Dangerous substances	4,578
Falling, rolling, and flying objects	2,632
Personal falls	8,404
General or all other causes	29,936
Unknown	720
Total	51,665

3249 TEMPORARY INJURIES OCCURRING IN AGRICULTURE
TIME: 12 MONTHS—JANUARY 1 TO DECEMBER 31, 1915

Amounts Paid in Compensation and Medical Benefits by Chief Causes

Cause	*Compensation*	*Medical Benefits*	*Total*
Machinery	$5,076.00	$7,819.58	$12,895.58
Dangerous substances	2,172.00	6,578.98	8,750.98
Falling, rolling, and flying objects	1,982.00	3,391.38	5,373.38
Personal falls	6,546.00	8,754.00	15,300.00
General or all other causes	20,745.00	36,778.23	57,523.23
Unknown	703.00	605.75	1,308.75
Totals	$37,224.00	$63,927.92	$101,151.92

In Illinois but 114 of the 16,869 accidents reported for the year ended June 30, 1916, were agricultural, less than 1 per cent., and of these, none was fatal. The compensation awards and medical expenses for this group amounted to $9531. The disability period terminations were as follows:

WEEKS								
Within:	1	2	3	4	5	6–10	11–15	16–20
	35	25	15	11	5	17	3	3

In Michigan the Report of the Industrial Accident Board for the year 1916 states that there were 343 agriculturalists under the Act—these employing 3004 workers. For the period covered there was one fatal accident, and one resulting in permanent partial disability. There were in addition 52 causing temporary total disability. The one case of permanent partial disability

was an accident resulting in loss of an arm by an employe operating agricultural machinery.

The classification of the agricultural accidents causing temporary total disability in Michigan is as follows:

	Fractures	*Dislocation or Sprains*	*Lacerations*	*Cuts*	*Contusions*	*All Others*	*Total*
General farming	7	3	4	2	1	2	19
Dairy farming	..	..	..	2	..	..	2
Stock farming	..	..	..	..	..	..	..
Garden and truck farming	5	2	..	2	2	6	17
Operating agricultural machinery	7	3	..	..	3	1	14
	19	8	4	6	6	9	52

In Minnesota for the year 1915–1916 there were 14 fatal accidents recorded in agricultural pursuits. Over the period 1910 to 1916 inclusive, 85 fatal accidents occurred in this industry. A special note is made in the Minnesota report of the inspections given agricultural machinery. In the last two years 29 orders were issued to guard danger-points on corn-shredding or corn-husking machinery. Inspections are made whenever the Department learns of any new models of such machinery being placed on sale by implement dealers in Minnesota. Orders are issued prohibiting its sale until properly guarded. Largely as the result of this safety effort manufacturers are now frequently inviting inspection of a working model before they commence its manufacture.

Though there are but a very few states in which compilation of any statistics on this subject has been made, even such as are available indicate the extent of the hazards of farm labor.

GOGGLES

Of the various protective devices which are available for the reduction of eye accidents in the industries, there is none which has greater possibilities for saving sight than the goggle. In

design, style, and color one has infinite variety of choice. Due to the activity of the commercial houses making a specialty of goggles and other protective appliances for the eyes, industrial managers and plant officials in every city and hamlet are more or less familiar with the purposes for which the various styles have been created, and the moderate prices at which they may be secured in either small or large quantities.

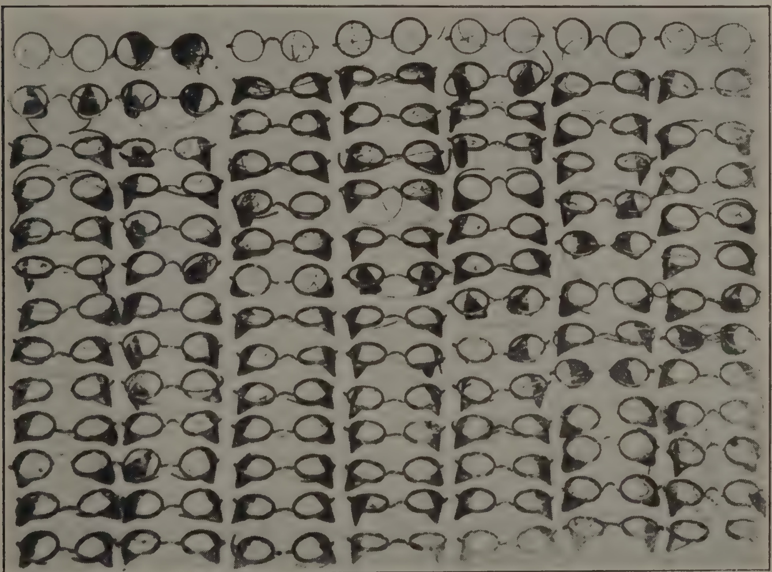

Fig. 38.—Ninety-four pairs of broken goggles collected in three months. Each pair saved a man's sight. American Steel Foundries.

The marked reduction in eye accidents which has been accomplished in an infinite number of great industrial organizations during the past decade is the result in large part of the provision and use of protective goggles.

During the year 1913, 2499 employes of the New York Central lines sustained eye injuries, many of which were serious. According to the statement of Mr. Marcus A. Dow, General Safety Agent of that System, every one of these cases might have been prevented if goggles had been worn. This railroad was the

first in the United States to adopt goggles in the campaign to reduce eye injuries, and the results secured have been remarkable. Chippers, riveters, boilermakers, grinders, or any employes doing work hazardous to the eye are furnished free of charge properly fitted goggles. These employes are constantly turning in goggles with cracked lenses, some shattered, others covered with splashes of molten metal, and some so scratched and checked from particles of emery that they look like ground glass. Each pair thus damaged attests the sight-saving potentialities of this kind of eye protection.

Any safety director or manager of a foundry or shop in which safety regulations are enforced can show numerous "exhibits" of goggles which have saved eyes. Within a period of but three months 94 pairs of goggles, each of which presumably saved a man's sight, were turned in at the works of the American Steel Foundries Company. Every pair had been broken by flying steel chips. In another large steel foundry where goggles have been used since 1911, 48 broken pairs were collected in one month's time from one plant—297 pairs among the several subsidiary foundries within a period of six months. During this entire period not one serious eye accident occurred.

The striking reduction in eye accidents as shown by the following record of injuries to the eyes of employes of the American Locomotive Company for a period of five years, during the latter two of which the use of safety goggles was established, provides a typical example of the excellent results which may be expected from the use of this kind of eye protection. (See table, p. 113.)

The different types of goggles in use may be classed under four heads:

1. Goggles for protection against flying materials.
2. Goggles for protection against intense light and heat.
3. Goggles for protection against gases, fumes, and liquids.
4. Dust goggles.

The first essential of any protective device is that it must offer complete protection against the hazard for which it was designed. In the matter of goggles, comfort is very important, and this necessitates light weight and good ventilation of the space around the eyes. The parts in contact with the skin

should be smooth and so well fitted that no chafing or discomfort will result. Bad-fitting goggles have created much prejudice against their use. Goggles can be bought in many sizes, and are made to conform to the wide nose of the negro, just as well as to the nose with a very narrow bridge.

AMERICAN LOCOMOTIVE COMPANY—NEW YORK

Injuries to Eyes—Years 1910 to 1915

Year	*Number Accidents Requiring Medical Attention*	*Number Eyes Lost*	*Average Number Full-Time Men Per Year*	*Number Full-Time Men Per Year Per Eyes Lost*	*Number Injuries Per 1000 Full-Time Men Per Year*	*Number Full-Time Men Per Year Per Injury*
1910	518	13	11,547	1,119	35.6	28.0
1911	293	7	8,358	1,194	35.0	28.5
1912	491	13	11,084	853	44.3	22.5
1913	490	9	12,042	1,338	40.7	24.7
(Average) 1910–1913	448	10.5	11,506	1,108	38.9	25.7
USE OF SAFETY GOGGLES ESTABLISHED						
1914	86	1	5,004	5,004	17.2	58.2
1915*	52	2	3,311	1,656	15.7	63.6

* Actual for first six months multiplied by 2.

Goggle manufacturers have given very careful attention to the tensile strength of both lens and frame. One test applied to the glass consists in dropping a hardened steel ball five-eighths of an inch in diameter 21 inches from an electric magnet directly upon the surface of the glass, without permitting the latter to rest on any support or backing other than its own frame. The goggles subjected to this test should withstand 25 blows of this kind without breaking.

Many workmen attempt to repudiate the recommendation that goggles should be worn with the objection that they are in themselves a source of danger, due to damage to the eye from possible cuts received from a broken lens. An eminent oculist who has had large experience in attending workmen who have sustained industrial accidents states, from his own personal ex-

perience in over 2000 serious accidental injuries to the eyes, that he has seen only three of any kind caused by broken goggles, and "none of these was serious." Again, the safety director of a steel plant employing nearly 20,000 workers in a southern city recently stated to the author that from more than 4000 accidents resulting in the breaking of lenses in goggles there had been not a single injury due to penetration of glass particles.

The lenses should be ground both sides to eliminate surface waves and defects, and glass that is at all off color should not be used. Frequently employers provide the goggles with lenses ground to correct some refractive error which exists in the eyes of the employe. Some corporations have the eyes of their workmen periodically examined, and treatment afforded as may be required. Workmen accustomed to wearing corrective lenses at their work may thus have them supplied in the protective goggle according to prescription requirements, and by this means do away with the trouble of wearing glasses under the goggles. Several Buffalo firms furnished these prescription lenses for their workmen free of charge, and the workmen wore the goggles continuously.

In addition to the foregoing recommendations, attention is directed to the following suggestions quoted from a National Safety Council Bulletin:

"The secret of getting men to wear goggles is to use a little patience. Induce the workmen to give the goggles a few days' trial. Inquire each day how they are getting along. Sometimes it is necessary to pick out one man who is sympathetic with progressive ideas and convert him. He will help convert the others.

"Provide a case with every pair of goggles. Money will be saved by so doing, and the life of the goggles will be prolonged.

"See that each man is provided with a cloth to clean his goggles. Renew the cloths frequently; this will encourage the men to keep their goggles clean.

"It is of the utmost importance that goggles be inspected daily for the following defects: Cracked lenses, bent or broken screens, loose temple pieces, etc.

"If a workman complains about his goggles, listen to him. The chances are that his trouble can be adjusted very easily.

"If education and persuasion fail to convince men that they

must protect their sight, there is only one course left, and that is discipline.

"When showing visitors through plant, ask them to comply with the shop rules and wear goggles in departments where such are in use."

It is of prime importance to emphasize the danger of infection and transmission of disease through any interchange of goggles

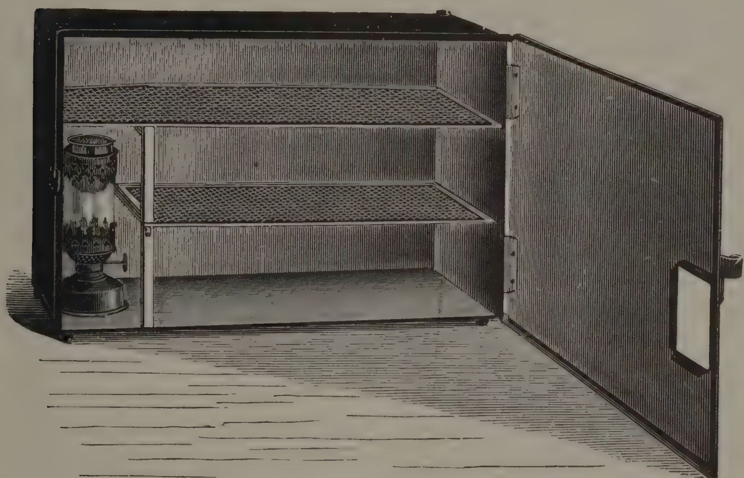

Fig. 39.—Sterilizer which can be used for disinfecting goggles with formaldehyde gas.

on the part of employes. And yet it must be admitted that under pressure of rush work, when scores of goggles are being turned in daily to have new lenses inserted, a workman will not always get back the same goggle frame he originally had.

If it is found impossible to label frames with employe's name or number, or to look after these details with sufficient care to insure the proper return of goggles, a sterilization outfit should be secured. Various types of these are on the market, used chiefly for sterilization of surgeons' instruments, but easily adaptable to the sterilization of goggles. The one illustrated in Fig. 39 may be purchased at small cost, and will thoroughly sterilize goggles, in quantity lots. But a short time is needed to ac-

complish the process. Lacking such special apparatus, the use of boiling water or live steam will prove effective as a means of sterilization.

The question as to whether goggles should be held in place by metal temple pieces or by an elastic band fitting around the head is one which should be determined in large part by the particular occupation and temperament of the employe.

While the elastic band may deteriorate from perspiration or stretching, it is easily and cheaply replaced, and may prove advantageous in unconsciously encouraging more constant use of the goggles. Workers using these head-bands have been noted as being accustomed to push the goggles up on their foreheads when not in use. While this procedure may to some appear disadvantageous, it has been evident to others that it made for more consistent use of goggles among those who were engaged in work which did not require constant eye protection.

GARMENT WORKERS

It has long been evident that garment workers suffer to a very great extent from defective vision. It has been recognized that the industry itself was one which called for close application to work in itself unusually trying on the eyes. The statements made in the paragraphs in this section are based not only upon the author's observations, but also upon the findings in a study of the health of garment workers, and the hygienic conditions of illumination in workshops of women's garment industry in New York city, conducted by the United States Public Health Service in 1914, and made under the personal direction of Surgeon J. W. Schereschewsky. The results of that investigation appear in Public Health Bulletin No. 71, issued May, 1915, and may be secured through the United States Public Health Service, Washington, D. C.

The study was made at the request of the Joint Board of Sanitary Control of the Cloak, Suit and Skirt, and Dress and Waist Industries of New York city, in which were employed at the time about 86,000 male and female workers. Of these, about 2000 male and 1000 female workers were examined.

The visual acuity was tested in the case of 1924 males and 982 females, a total of 2906 persons. Of this number but 743 (502 males and 241 females) had normal vision in both eyes, or a little over 25 per cent. of the total number tested. In 498 cases (341 males, 157 females), or a little over 17 per cent., the vision was normal in one eye, but defective in the other, while in 1665 instances (1081 male, 584 female), or about 57 per cent., the vision of both eyes was defective.

The relation between the occupation of the worker and defects of vision is shown by the fact that the incidence of subnormal vision in both eyes among males appeared in 64.6 per cent. of the finishers, 64 per cent. of the tailors, 58.7 per cent. of the pressers, 52.7 per cent. of the operators, 48 per cent. of the miscellaneous workers, and 44.6 per cent. of the cutters. Among females the percentage incidence of subnormal vision in both eyes was as follows: Finishers, 60 per cent.; operators, 57.7 per cent.; miscellaneous workers, 57.1 per cent.

With the exception of the work of the pressers, the garment industry makes exacting demands upon the eyes of the workers. Eye-strain may easily develop, and it is important that any defect of vision be recognized at an early stage and the proper treatment and glasses provided. Those who made the greatest use of their eyes were found to have the highest percentage of defective vision, and the percentage of those having normal vision was in inverse proportion to the age, the groups with the highest average age having the lowest percentage of normal vision.

So far as the workers' responsibility is concerned, it would seem that faulty posture and neglect of personal hygiene were the factors chiefly responsible for the ocular conditions found.

Dr. Schereschewsky found that, "in spite of the large number of workers with defective vision, relatively few had made any attempt to improve their vision by the use of glasses." In fact, only 11.7 per cent. of the 2163 male and female persons with defective vision wore glasses, and of these only about 20 per cent. wore glasses which would wholly correct the visual defect. Partial correction of the visual defect was present in 163 cases, or about 64 per cent. of those wearing glasses, while in 36 cases, or

about 14.4 per cent., the glasses worn either did not improve the vision or made it worse. Compared with the total number having defective vision these percentages become smaller yet, those with defective vision having their defect fully corrected by glasses being but 2.35 per cent., those with the defect partly corrected being 7.5 per cent., and those wearing glasses without improvement being 1.67 per cent."

In explanation of the great prevalence of defective vision in these workers there should be considered the fact that many are foreigners not accustomed to our ways, afraid to go to the hospital or to an eye clinic, and too often yielding to the temptation of purchasing glasses from a push-cart, thus attempting to diagnose their own needs, and merely temporizing with the defect. Again, many glasses had undoubtedly been prescribed by opticians or practitioners poorly qualified for such work. In certain instances the defect was such that partial correction was the best that could be secured.

The correction of certain faults for which the workers themselves are responsible will rapidly better conditions. To effect this, the following recommendations were made:

"Owing to the great number of faulty postures among workers, the fatigue from sitting on seats improperly supporting the body and similar conditions, an effort should be made to promote the use in the garment trades of adjustable seats with backs."

"In view of the efficient organization of garment workers and the relative ease with which information can be disseminated among them, the suggestion is made that the trades establish a special dispensary for garment workers . . . where special attention will be paid to the correction of ocular defects, dental prophylaxis, and disease of the respiratory and digestive tracts."

Regarding the causes of defective vision over which the workers have no control, a study was made of the hygienic conditions of the 34 shops and 45 workrooms typical of the women's garment industry in New York city. The study was made during the summer months, when, because of the better daylight conditions, the optimum light condition might be expected.

All the shops used daylight, but at 23 per cent. of them it was found that auxiliary artificial illumination at some working-

Fig. 40.—Operatives sewing in a sweat-shop, the only artificial illumination being that of one open-flame gas-jet.

Fig. 41.—Lighting of sewing machines. Consolidated Gas Company of New York.

place had to be depended upon habitually. Because of reduction of the efficiency of windows due to small sky angles (hence high angle of incidence of light); failure to use prismatic or factory-ribbed glass with windows of small sky angle; dirty windows and reduction of daylight due to obstruction of window-spaces by piles of clothing, et cetera, the illumination at the working-places was found for the general average to be inadequate in 52.6 per cent. of the shops inspected. These computations were based upon the requirement that all working planes should have a minimum average illumination of 5 foot candles, which is somewhat higher than that ordinarily required for other types of work, and is so set because of the exacting natures of the work involved. A study of the albedo or reflection co-efficient of the various cloths worked upon indicates clearly the need for more than ordinary amount of illumination. Glare effects were found, as were also lack of uniformity in distribution of illumination, inadequate illumination, and troublesome shadows.

ALBEDO OF MATERIALS COMMONLY WORKED UPON IN WORKSHOPS OF THE WOMEN'S GARMENT TRADES, NEW YORK CITY

Material	*Albedo*	*Material*	*Albedo*
	Per Cent.		Per Cent.
Black velvet	0.37	Black silk and mercerized cotton	4.5
Navy blue woolen cloth (dark)	1.7	Green (light) woolen or cotton	5.4
Black woolen cloth	1.9	Brown woolen cloth (light)	10.9
Navy blue woolen cloth (light)	2.2	Tango cloth, woolen or cotton	14.3
Green, Russian (dark), woolen or cotton	2.3	Light brown paper patterns	35.1
Brown woolen cloth (dark)	2.3	White cloth*	65.9
Black cotton cloth	2.9		

* The albedo of white cloth depends largely upon its thickness, together with the color of the surface upon which it is placed. The albedo given is for a double thickness of cloth lying on a golden-oak colored surface.

The recommendations which were made for providing adequate illumination so far as daylight is concerned specified that the building in which a garment shop is located should be on a street having general east and west direction, that preference should be given to upper floors because the sky angle increases

as the height from the street; that the imminence and color of neighboring buildings should be carefully considered, especially if a workroom is set on a low floor; that with small sky angles, prism or factory-ribbed glass should be used for windows; that the ceiling height should be the greatest available; that walls and ceilings should be finished with a white mat surface and trim and doors be light in color.

The arrangement of working planes should be perpendicular to the windows. This, while not ideal, owing to the fact that workers are placed at both sides of the tables, is nevertheless considered the best practical working out of that problem. The number of machines in a bank should be limited to six or eight. Placement perpendicular to the windows will eliminate the possibility of glare from daylight sources, and minimize the shadows on the working surface.

So far as artificial lighting is concerned, it is recommended that the entire shop have a system of general artificial lighting sufficient to insure an illumination of not less than one foot candle over the entire floor area. Work planes should have from 5 to 7 foot candles illumination; there should be local lighting for machines and finishing tables, and general illumination for cutting, basting, and pressing tables. It is as important to avoid glare from artificial, as well as from natural, light sources. Bare lamps should never be used, and care should be exercised to prevent a local light source being so manipulated by a worker as to produce satisfactory illumination for himself and yet cause glare for an adjacent worker. Prismatic reflectors should be of the deep-bowl type, so that the light units will be concealed. Opaque deep-bowl or cone reflectors should always be used for local illumination when the height of suspension is such that the light unit will be within the ordinary field of vision.

INDUSTRIAL LIGHTING

The advantage of correct lighting in all industries is now generally appreciated by all who have considered the problem. The influence of correct shop lighting as an aid to increased production and improved quality of work has been the subject of

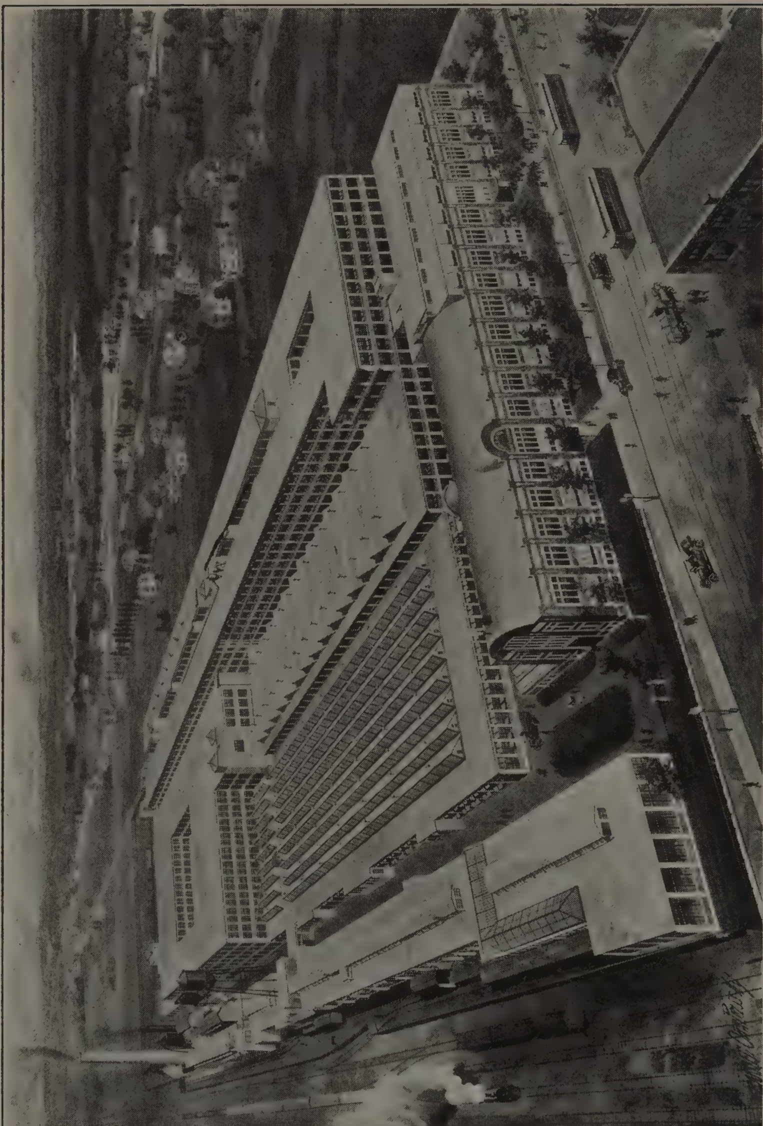

Fig. 42.—Plant of the Pierce-Arrow Motor Car Company, Buffalo, N. Y. Great window area, saw-tooth and monitor roof construction make for the utmost use of natural light.

much study and attention, and the results have proved to the satisfaction of many, that with the installation of proper lighting equipment there follows a marked increase in the amount of work done, the quality of work is improved, the number of "seconds" is reduced, accidents are less frequent, and in many instances the cost of lighting itself is lowered.

Undoubtedly more agreeable and comfortable working conditions are brought about when proper lighting is provided in work-places, and protection thus given to the eyesight of the workers.

These factors are so important from the humanitarian standpoint and from their close connection with production, labor turn-over, and other shop problems that it is hard to understand why all industrialists do not provide satisfactory illuminating conditions in all departments from office to foundry.

Good illumination is an excellent business proposition. It has been shown that production may be increased from 8 to 15 per cent. (depending on the particular industry) by the installation of proper lighting equipment in plants which have hitherto lacked this advantage. The cost of correct lighting is not to be compared with the results obtained, since the item is usually less than ¾ of 1 per cent. of the workmen's wages when all charges are included.

"One of the leading electrical engineers of the United States has made a careful study of factories in which efficient lighting systems have been installed. He states that, as a result of *improved lighting systems* in steel plants, where coarse work is done, the total output was increased 2 per cent.; in plants such as textile mills and shoe factories, where the work is finer, the total output was increased 10 per cent.

"We have been informed that recent investigation reveals the fact that the cost of providing adequate artificial illumination in the average plant does not exceed ½ of 1 per cent. of the wages. It costs one cent a day to provide a man earning $2 a day with sufficient light so that he can work with accuracy and safety."—*News Letter No. 10, National Safety Council.**

* This quotation originally appeared in a paper entitled "Industrial Lighting," prepared by Mr. C. L. Eshleman, published in the Proceedings of the American Institute of Electrical Engineers, January, 1913, pages 41 to 54.

For specific data relating to results of the nature mentioned, the reader is referred to the following articles:

"How to Increase Factory Efficiency," by O. M. Becker, Engineering Magazine, April, 1916.

"Gas Lighting in Industrial Plants," by Thomas Scofield, Engineering Magazine, October, 1916.

"Light as a Factor of Efficiency," by W. A. D. Evans, Textile World Record, issues of November and December, 1914.

"Artificial Lighting and Shop Production," by D. R. Shearer, Electrical Review and Western Electrician, July 1, 1916.

There are those who feel that too much emphasis has been put on illumination as a factor in accident reduction. For instance, Beyer in "Industrial Accident Prevention" makes the following statement:

"It has been assumed that inadequate lighting facilities brought about many of the accidents which occur in the industries during the winter months, but there is really no way of proving such a statement. Many comparisons have been made of the number of accidents which have occurred in the summer and winter months; because certain tables of statistics show fewer accidents in summer than in winter it has been assumed that the difference is due to the greater prevalence of daylight in summer. This conclusion is scarcely permissible, since the benumbing effect of cold weather furnishes quite as reasonable an explanation for the increased accidents in winter as does inadequate light."

As to the hours of the day between which the largest number of accidents occur, it has long been recognized that the peaks are between 10 and 11 in the morning, and between 4 and 5 in the afternoon. It would therefore seem that fatigue might be a factor chiefly responsible for accident occurrence, and of the causes of fatigue, aside from the nature of the work, the physical condition of the employe and the working conditions would seem to be the most important. Under "working conditions" illumination is an important factor in the establishment of good or bad working conditions.

The chief barrier in the way of improvement of illuminating conditions is generally found to be the first cost of installation.

The facts, however, do not justify such an attitude. The opinions of many plant officials throughout the country have been sought in regard to the effect of illumination on production, health, efficiency of workers, and accident prevention. The majority of replies stated that with the improvement of lighting conditions there have been marked changes for the better in output, attitude of workers, and accident reduction.*

If in the 70 plants visited in Buffalo it were possible to place the buildings in groups according to the nature of the work performed within them, arranging the individual buildings of each group in line, beginning with the oldest, the result would show a most remarkable progress in the development of better daylight conditions. Even in a single plant this progress can be observed.

Perhaps the most striking instance was the plant of a firm engaged in the manufacture of metal beds. The oldest building was of brick, with low ceilings and narrow windows spaced at irregular intervals. The rooms were wide and received very little daylight. New buildings which had been added from time to time showed the tendency to provide more daylight. The ceilings were higher and the rooms were narrower. The windows were also higher and closer together. The most recent addition consisted of a two-story reinforced concrete daylight building, the design of which was such as to permit its extension to five stories at some future time. Many other examples could be cited to show this increasing tendency to provide an abundance of daylight when additions to the plants are made.

There are several Buffalo firms whose plants are worthy of mention as having extremely good daylight features. Among these are the Hewitt Rubber Company, the Otis Elevator Company, Ford Motor Company, Barmon Brothers, Inc., and the Pierce-Arrow Motor Car Company. These plants present many different conditions and all are worthy of study for daylight features alone.

* The reader is referred for further particulars to the following article: "The Consideration of Color, Design and Acoustics in Factories," by Florence Dempsey, in "Safety," October, 1914. The article is published as a report on progress by the Committee on Factory Planning, of the American Museum of Safety. Frank E. Wallis, F.A.I.A., was Chairman of the Committee. The article referred to is a summary of the replies received to a list of questions sent to two hundred factories in various parts of the country.

Fig. 43.—Interior view of assembly room of Pierce-Arrow Motor Car Company, Buffalo, N. Y., showing daylight illumination secured by physical construction of plant, as illustrated in Fig. 42.

The Pierce-Arrow Plant has given a great deal of attention to the question of lighting. Their plant may be studied to great advantage by any one interested in this feature of plant equipment.

The buildings are of reinforced concrete and steel construction, rising to four stories. Monitor, saw-tooth, and skylight construction are used in the one-story buildings. The saw-tooth windows face the north and east. This type of daylight construction is particularly efficient in providing light for the shop where the machine-belting, the shafting, and machines themselves create difficult lighting problems. Where freight cars are likely to cut off light from the buildings, skylights have been provided.

In the four-story buildings the width is comparatively narrow and the windows extend to the ceiling. The ceilings in all the buildings are above average height.

The interior of the plant is painted throughout in a light color. Factory green or other neutral tint is applied to a height of about five and one-half feet from the floor. The wide space between buildings and the light walls are of great importance in securing good light.

Window-shades are provided where the direct rays of the sun might be a source of annoyance to the employes.

Many of the *small* foundries in Buffalo were found to have poor daylight conditions. Most of the buildings were old and the window-space limited. Moreover, little or no attention was being paid to the light-producing possibilities in *clean* windows. The value of light wall coloring of high reflective power as an aid to interior illumination appeared to be recognized in but one of the small foundries inspected.

Clean windows will go far toward solving the lighting problem for many plants. Wherever possible, windows should be thoroughly cleaned at least once weekly. The increase in efficiency in the workmen, the decrease in accident hazard, and the expenditure for artificial light are all items that would thus be materially affected.

In a number of plants which were equipped with an abundance of window-space it was found that the accumulated dust, grease,

and grime on the window-panes cut down the natural illumination almost to zero—so much so, in fact, that it was necessary during practically all the working hours of the day to resort to artificial light.

Experience in many progressive foundries throughout the country has proved the value of light wall coloring as an adjunct to natural and artificial light. Walls and columns should be cleaned at frequent intervals, by brush or air, if all the value of their reflective powers is to be held. In general it may be said that if the available lighting facilities of the average foundry were properly maintained, most of the dark spots now illumined with an incandescent would be sufficiently served by sunlight.

The finishing of factory and shop walls in white was carried out in practically every plant where the dust accumulation was small. This applies to machine shop, the textile and garment-making industries, breweries, factories in loft buildings, etc.

Many of the older buildings in the acid plants inspected in Buffalo were lacking in daylight. The window-space was small, and the arrangement of equipment cut down the light. In the buildings of recent construction the ceilings were higher, window-space more ample, and monitor roof construction frequently employed. The newer buildings themselves were found to be narrower as compared to the length. This, with the higher ceilings, makes for better daylight conditions.

The contrast between a shop with a systematized lighting arrangement and one poorly equipped is very marked. The dark spots and shadows of the latter make for a disorderly appearance, and the effect as one passes from a brightly illuminated space to one of comparative darkness is to make one more or less uncertain in his movements. The workman is influenced by this lack of uniformity and cannot help but fall into unsystematic habits. In other words, the moral effect is bad. The neat, orderly appearance of the wood-working shop illustrated on p. 130 would be completely altered had the lighting equipment been arranged in a haphazard fashion. It is well to note the efficient type of reflector used in this shop, as well as the white walls and ceilings, which also act as reflectors and make for cheerful working conditions.

Standards for the illumination of various departments and conditions have been prepared by illuminating engineers, and for those seeking a manual of such information there is recommended the "Code of Lighting Factories, Mills, and Other Work Places," prepared by Committees of the Illuminating Engineering Society, 129 West 39th Street, New York, and issued under the direction of the Society.

While the code is intended as an aid to industrial commissions and other similar bodies in those states and municipalities which shall actively take up the questions of legislation as related to factory and mill lighting, it is intended in equal measure for the industries themselves as a practical working guide in individual efforts to improve lighting conditions. The language of the code has not been drafted according to legal phraseology, but is simple and pointed throughout, thus readily available for transforming into legal orders, and at the same time as a working guide in practical design and installation work.

Recommendations: In illumination, two forms of light must be considered, viz., natural and artificial. The two undesirable features common to both are undue brilliancy or "glare" and heavy shadows.

Glare may be caused if the angle between the direction of vision of the eye when applied to the work it is called upon to do and the line from the eye to the source of light is too small. The minimum angle may be provisionally assumed to be 30 degrees. (The Illuminating Engineer, Vol. 3, 1910, Prof. L. Webber.)

Glare may be caused also by reflection of images of light sources from glossy or polished surface viewed. It may be mitigated or eliminated by reducing the brightness of light sources and by eliminating polished surfaces where practicable.

Heavy shadows may be avoided by having the sources of light distributed as evenly as possible, and by making adequate provision for diffusing the light throughout the room. This diffusion is best effected by having decorations in light colors, by the use of prismatic or ribbed glass in windows, and by suitable shades or reflectors on the lights. Shadows have a certain value in assisting the eye to gage distance and direction; the common failing is too little, not too much, diffusion.

Fig. 44.—An excellent example of modern lighting installation in woodworking shop.

Fig. 45.—Artificial lighting in machine shop. Note use of angle reflectors under crane track.

In regard to adequate window area in proportion to floor area, Mr. D. R. Wilson, in a special report on illumination in factories (see Annual Report, English Factories and Workshops, 1911), recommends that the window area be at least 10 per cent. of the floor area served, 20 to 30 per cent. being generally desirable.

Direct light from the sky is much stronger than reflected light, so it is important to have high rooms with the windows as near to the ceiling as practicable. A few inches added to the height of the windows may make a great improvement in the illumination, particularly in the center of the room, where the light is poorest.

Removal of obstructions, and the proper arrangement of machinery in relation to place of windows, have much to do with securing proper illuminating conditions. The machines should be placed in rows which run at right angles to the wall containing the windows, so that there will not be the glare of daylight directly in the eyes of the operators, or the occurrence of heavy shadows on the work because of the interference of the workman's body with the diffusion of the daylight.

Ideal conditions can be more easily secured with artificial light than with natural light; it is easier to control the intensity and location of the former. In the arrangement of artificial lights, the size of light units required should be decided in part by the height of the ceilings. In low rooms small units spaced at frequent intervals are most desirable, while where the ceilings are high, larger units with wider spacing should be used to prevent glare and provide even distribution over the floor area.

The location of light units should correspond with the foregoing suggestion that an angle of not less than 30 degrees should be subtended from the source of light to the eye, and thence to the work.

The intensity of illumination needed for different operations is an exceedingly variable quantity, for which it is difficult to outline definite standards. It is governed by the nature and degree of fineness of the work to be done; by the quality of the

surface worked upon (whether light or dark in color, rough or polished, etc.), and to a certain extent by the visual requirements of each individual.

The National Electric Light Association, New York, has provided a list based upon data which it has secured, which indicates the approximate amount of illumination considered desirable in certain characteristic industries. The reader is referred to their publication, entitled "Industrial Lighting." Also, the

Fig. 46.—Semi-indirect office gas lighting. Note the absence of shadows even on the ceiling. Consolidated Gas Company of New York.

Illuminating Engineering Society, New York, has for distribution a valuable booklet entitled "Light, Its Use and Misuse," which can be secured from any lighting company.

The National Committee for the Prevention of Blindness receives many inquiries for information in regard to illumination. To certain of these inquiries its Sub-Committee on Illumination has prepared replies. From the information thus made available the following notes have been prepared:

Office Lighting.—In large installations of importance expert advice should be obtained if best illumination results are to be had. Often useful assistance can be obtained from local lighting companies. For general guidance, however, it may be stated that illumination of the order of 4 foot candles (lumens per square foot) on the working plane is regarded as reasonably satisfactory for the generality of offices. Under various conditions illumination of this value may be obtained with energy expenditure of the order indicated in the following table:

WATTS PER SQ. FT. TO YIELD 4 FOOT CANDLES (LUMENS PER SQ. FT.) *

Finish		*Direct Lighting System*		*Semi-Indirect Lighting System*		*Indirect Lighting System*	
		Tungsten Filament Lamps					
Ceiling	*Walls*	*Vacuum*	*Gas Filled*	*Vacuum*	*Gas Filled*	*Vacuum*	*Gas Filled*
White	Light	0.67	0.55	0.89	0.74	1.15	0.95
Cream or ivory	Medium	0.73	0.60	1.0	0.83	1.33	1.11
Light buff	Dark	0.8	0.67	1.14	0.95	2.0	1.67

GAS MANTLE LAMPS (INVERTED)
CU. FT. OF GAS PER SQ. FT. TO YIELD 4 FOOT CANDLES (LUMENS PER SQ. FT.)†

Finish		*Direct Lighting System*	*Semi-Indirect Lighting System*	*Indirect Lighting System*
Ceiling	*Walls*	*Cluster Units*	*Cluster Units*	*Cluster Units*
White	Light	.030	.042	.084
Cream or ivory	Medium	.036	.050	.100
Light or buff	Dark	.042	.058	.146

* The data regarding electrical illumination were compiled by the Electrical Testing Laboratories, New York, at the request of the Committee.

† The data regarding gas illumination contributed by the Consolidated Gas Company, New York.

That is to say, depending upon the reflecting qualities of the interior finish of the office and upon the character of the lighting

equipment, as well as upon the type of lamps used, one may obtain illumination of 4 foot candles on the working plane with expenditures of energy ranging from a minimum of 0.55 to 2.0 watts per square foot for electric lighting, and a minimum of .030 to .146 cu. ft. of gas per sq. ft. for gas lighting. Illumination of higher intensity may be obtained under like conditions with proportionately greater expenditures of energy.

It is customary in office lighting to install lighting fixtures in the center of rooms or bays where the room or bay is high in relation to its length and width. If the ceiling is low in relation to the length or width, it may be necessary to install the fixtures in the middle of imaginary rectangles into which the room area may be divided.

Whatever the type of installation adopted, whether direct, semi-indirect, or indirect lighting fixtures are used, a fairly high degree of diffusion is important in office lighting. The surface from which the light is derived should be relatively large in order to obtain such diffusion.

Equipment.—Diffusion of light effected by a globe, shade, or reflector depends chiefly upon the area of the surface from which the light is distributed, and upon the finish of that surface. Increased area and more diffuse or mat finish brings increase in diffusion. While it is not necessarily the case, yet in practice highest diffusion generally is obtained by the use of indirect lighting fixtures, the lowest diffusion by the use of direct lighting fixtures. Semi-indirect lighting fixtures range from a degree of diffusion of the same order as direct lighting fixtures, to a degree of diffusion of the order of indirect lighting fixtures. That is to say, dense semi-indirect bowls which, when installed, are no brighter than the ceiling above them, produce the same order of diffusion as opaque indirect lighting fixtures. While it is not necessarily the case, yet it is generally a fact in practice that increase in diffusion is accompanied by decrease in the percentage of light delivered upon the most useful plane. For various purposes particular degrees of diffusion are most desirable. When the desired degree of diffusion for a given installation is ascertained, it can usually be obtained in a satisfactory manner by one or more of the types of fixtures which have been mentioned.

When the indirect system of lighting was first developed, it differed radically from the direct system of lighting then in general use. Later the semi-indirect system became likewise popular and the development of the past few years in each type of lighting has been in the direction of a common result, lying between the extremes represented by the original direct and indirect lighting systems.

Generally speaking, higher degrees of diffusion are required for exacting work on plain surfaces, such as reading, writing, drafting, et cetera. Ordinarily, such diffusion is obtained at the expense of definite direction for the greater part of the light. Where good appearance of a room is the principal requirement, a high degree of diffusion generally is not desired, because without a dominant direction for most of the light, the room appears flat and perspective is lacking.

Local *vs.* General Illumination.—Experience indicates that in most industrial installations reliance should never be placed exclusively upon local illumination. There should always be some general illumination in order not to subject the eyes to extreme contrasts of light and shadow when directed toward the place illuminated locally and when directed elsewhere. In some classes of work general illumination alone may serve. In others, general illumination supplemented by local illumination yields best results.

Daylight Illumination.—Illumination by daylight is a complicated problem. With windows of a given size the amount of daylight admitted would depend upon the exposure to the sky. Direction of exposure, obstructions such as buildings, trees, etc., reflecting qualities of such obstructions, also the thickness of the walls, the dimensions and interior finish of the room, are factors which affect the light admitted by a given window. The Illuminating Engineering Society has prepared a Code of Lighting School Buildings from which the following statements are taken:

Rooms more than 20 feet in width can rarely be lighted satisfactorily from windows on one side only. When the lighting is from windows on one side of the room, the area of the windows ought to be at least 25 per cent. of the floor area. When the lighting is from two sides of the room, the window area ought

not to fall below 20 per cent. of the floor area. The reader is likewise referred to the Code of Lighting Factories obtainable from the same source.

Good results are obtained if no part of the room is more distant from a window than twice the height of the top of the window from the floor. With unobstructed horizon good results have been found when the visible sky subtends at least a vertical angle of five degrees at any working point of the room.

THE SAFETY MOVEMENT

With the safety problem in general it is not the function of this publication to deal. But it may be of service to list briefly the activities of those organizations which are engaged in nationalizing safety effort, in order that any who are not familiar with their undertakings may know what is being done, and how.

The problem that presents itself to any industrial concern which undertakes the task of accident prevention is (1) to provide proper and safe working conditions, and safeguards for dangerous machinery, (2) to educate the workman in the hazards of his particular department of work and the use of protective devices, (3) to see that the protective devices are used as intended.

Certain agencies are engaged in the philanthropic effort of making worktime a safe time for men and women. A brief description of the service being rendered by two of the chief of such agencies is given herewith.

THE NATIONAL SAFETY COUNCIL

(*Headquarters, Chicago, Illinois—W. H. Cameron, General Manager*)

The membership of the National Safety Council, an organization less than five years old, now numbers 3293 industrialists, with over 15,400 representatives and 4,500,000 workmen.* As a part of the safety service rendered by this organization, over five million bulletins in brief, pointed paragraphs, aptly illustrated, were issued during the year ended July 31, 1917. Posted weekly on factory bulletin boards, under the time clock, or at other

* Annual Report of the General Manager for year ending July, 1917.

prominent places, these bulletins have driven home the lesson of safety, time and time again—ofttimes telling their story so lucidly by illustration alone that their meaning was plain even to those workmen from "the old country" who could not as yet read the text.

There are now 33 State and Local Councils which have been organized by the national organization. They have provided the impetus which has in many cases been solely responsible for the enlistment of new recruits to the safety movement.

Fig. 47.

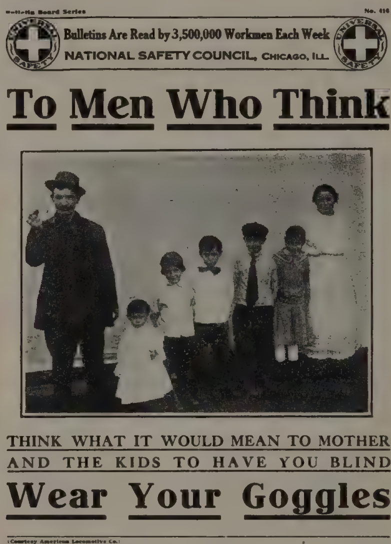

Fig. 48.

When the United States entered the war, the services of the Council were offered to the Federal Government. This step resulted in its taking the leadership in preparing plans for assisting the Government in supervising the safety of workmen in its plants during the war. Out of these activities there came a request from the United States Employees Compensation Commission for skilled aid in directing and supervising safety surveys in all the Government navy yards and arsenals. One of the

executive officers of the Council was detailed for this service, in which he is now engaged.

In the publication of special pamphlets on safety problems, and in the preparation of traveling exhibits, there is presented the most comprehensive and practical information obtainable upon the subjects treated. Briefly, the Council aims "to prevent accidents, to educate safety committees and the public to the real facts connected with needless accidents, and to propagate continually the safety idea and make it an integral part of American life and a growing influence in foreign countries."

Various forms of organization and methods of carrying on the educational campaign have been tested in the leading industries throughout the country, and a compilation of the results secured would indicate that the suggestions offered in the following brief résumé on safety organization methods are the best methods to be adopted.

The organization should revolve around a Central Committee which has jurisdiction and supervision over the work at all the plants, and is composed of representatives from each of the plants. This Committee is served and advised by the surgical and safety departments, and by special committees, such as master mechanics, electrical engineers, etc., composed of specialists from all plants, who investigate special and technical questions, reporting their conclusions to the Central Committee. Through the plant organization the Central Committee is also served by the entire operating and engineering force of each plant in one way or another. It is in this way that it obtains the best intelligence and the widest range of experience possible, and can therefore make the wisest recommendation. In the same way it is also enabled to act as a clearing-house between the plants, for all sorts of safety information and data, so that the best plans and ideas arising in each plant are made available to all.

Subordinate to the Central Committee is the Plant Committee served in the same way by safety inspectors, subcommittee, etc. Each performs at the plant and between departments at the plant the same functions that the Central Committee does in its work. Subordinate to the Plant Committee are the department superintendents, and to them, foremen and

gang safety men; the safety instructor (who is an instructor of new men) and workingmen's committees, which inspect their departments and investigate accidents.

The foregoing outline of a plan for safety organization may appear at first glance to be applicable or necessary to large industrial organizations only. However, it is suggested that in small plants employing say less than 250 men, the Superintendent may perform the same functions as the Plant Committee in large plants. He is served by subcommittees for investigating special and technical questions, and by his foremen, who perform inspection duties of the Safety Instructor of large plants, and also by workingmen's committees. Every grade of operative should be included. It has been found that it is only where the workmen themselves are given a place and part to perform in the organized effort to eliminate industrial accidents that satisfactory results can be obtained.

THE AMERICAN MUSEUM OF SAFETY

(*14–18 West Twenty-fourth Street, New York. Arthur H. Young, Director*)

The American Museum of Safety was organized and is maintained for the prevention of accidents, the elimination or lessening of occupational diseases, and the promotion of industrial welfare through health efficiency and coöperation.

There are now 26 museums of safety and institutes for the study of industrial hygiene in the world. The American Museum of Safety—twelfth in the world series of museums—is located in New York City, at 14 to 18 West Twenty-fourth Street, where it occupies the street floor, mezzanine, and basement. Its collections include not only actual devices and models of safety and sanitary appliances, but also a highly specialized library of books, pamphlets, reports, photographs, and lantern slides illustrating the simplest and most practical methods of protecting dangerous machines and processes. The Museum is absolutely non-commercial and does not sell or take orders for any of the devices it exhibits.

Annual awards of medals are made to those companies or individuals who have, during the previous year, done most to conserve the safety and health of their employes or the public.

CONCLUSION

That the safety movement has proved effective in reducing industrial accidents is unquestioned. That, in spite of temporary setbacks, it will be increasingly effective, is assured. It is not too much to hope that the day may come when employers and employes alike in *every* industrial occupation shall engage themselves in a constant effort to eliminate the great needless waste of life, with the suffering and economic loss that still loom annually to such gigantic proportions in our country.

As to statistics relative to accident reduction, the following paragraph,* cited in part heretofore, is encouraging:

"The available data do not permit of an absolutely definite assertion at this time as regards the saving of life and limb which has resulted from the modern Safety First Movement. On the basis of the most trustworthy available data, chiefly such as are derived from recent reports of industrial accident commissions, it would seem a conservative assumption that the number of fatal industrial accidents estimated for the year 1913 at 25,000, will during the year 1916 be reduced to about 22,000. The number of serious injuries involving a labor loss of three weeks or more, estimated at 700,000 for 1913, will be reduced to about 500,000. All such estimates in the absence of accurate and complete official statistics are necessarily merely an approximation to the truth. When the time limit of physical disability is placed at six weeks or more, the probable number of serious accidents has been reduced during the last three years from about 300,000 in 1913 to 260,000 in 1916. On the basis of this estimate, which is quite conservative, there has, therefore, been an approximate reduction of 12.3 per cent. in fatal industrial accident frequency during the last three years. The corresponding decrease in serious industrial accident frequency has been approximately 28 per cent."

One of the great factors responsible for the reduction in industrial accidents has been the increasing spread of compensation legislation. Employers in states where such laws now obtain have rapidly learned that the best way to eliminate casualty expense is by casualty prevention. From a purely commercial

* "Achievements and Possibilities of Accident Prevention in American Industries," Frederick L. Hoffman.

standpoint there is also the stimulus provided by the material reduction in the cost of insurance, the reduction being "based on the extent and effectiveness of accident prevention."

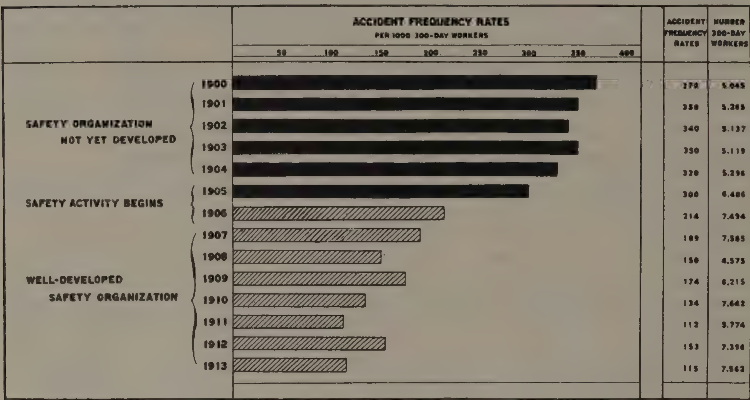

Fig. 49.—Accident frequency ratio in a large steel plant, 1900–1913, showing a 70 per cent. reduction in accidents. United States Bureau of Labor Statistics.

The records of scores of industrial concerns might be cited, showing splendid results in the reduction of industrial fatalities and accidents since safety effort has been inaugurated. The results in certain of the leading industries in the country have been almost phenomenal, especially when the brief space of time is considered during which safety effort has been in vogue.

THE NATIONAL COMMITTEE FOR THE PREVENTION OF BLINDNESS

In conclusion, it may be apropos to mention briefly the activities of the National Committee for the Prevention of Blindness, in the educational work which it has undertaken for sight-saving in the industries.

The objects of this Committee are: 1. To endeavor to ascertain, through study and investigation, any causes, whether direct or indirect, which may result in blindness or impaired vision.

2. To advocate measures which shall lead to the elimination of such causes. 3. To disseminate knowledge concerning all matters pertaining to the care and use of the eyes.

The Committee serves as a bureau of information and an agency of helpfulness to all who are interested in the movement to prevent needless blindness and to conserve vision.

That part of its program which has been devoted to the prevention of eye accidents in the industries has been carried forward in large part by coöperative effort with National, State, and local Labor Departments and Commissions, the National Safety Council, and the American Museum of Safety.

The Committee's publicity efforts in this work have been devoted during the past year to the distribution of nearly fifty thousand sets of large posters for bulletin board use. Reproductions of the posters are shown in the frontispiece of this publication. These have, during the past year, been displayed in factories, shops, etc., from the Atlantic to the Pacific. Each poster is approximately 16 by 33 inches in size. The original exhibit, of which each panel is 3 feet wide by 6 feet high, is almost constantly on display at conventions or other national and state meetings of manufacturers and safety directors.

In Alabama, Minnesota, Ohio, Pennsylvania, Utah, Washington, and Wisconsin, State Commissions are now bringing this educational material directly to the attention of manufacturers who report eye accidents. The following letter, sent out as a routine measure in Utah, will indicate how this service is maintained:

THE INDUSTRIAL COMMISSION OF UTAH

STATE CAPITOL, Salt Lake City, Utah

File No.
Date
Employe
Employer

We beg to acknowledge receipt of your report in the above accident.

Eye accidents to employes of Utah industries are becoming

altogether too numerous, and the compensation and medical expense in connection therewith enormous. Accidents to the eyes of employes are not only expensive to the industries, but are among the most serious in reducing the efficiency of the workmen.

Many of these injuries can be prevented by the installation of safeguards and by compelling employes to wear goggles while working at machines, emery wheels, chipping, or where liability of eye injury is great. The use of screens, carefulness regarding tools, and the inculcation of careful habits among workmen have been instrumental in many plants in reducing this type of accidents.

Education of the workmen is an essential precaution in all accident prevention work; warning signs and posters conspicuously posted calling attention to the serious consequence of carelessness and thoughtlessness are of great practical value in educating workmen.

To this end The Industrial Commission of Utah has undertaken to forward, and recommends the use of, the enclosed coin card, furnished this Commission by the National Committee for the Prevention of Blindness, 130 East 22d Street, New York City, by all employers of the State of Utah where eye injuries occur, and if there is anything further this Commission can do to assist employers throughout the State in reducing the hazard of accidents to their employes, we will be glad to render such aid as we can.

Respectfully yours,
(Signed) P. A. THATCHER,
Chairman.

Publicity effort has been still further carried on by the Committee through "shop talks" in numerous factories, these being given by the Directors, Advisory Members, or Executives of the Committee. That a lecture of this nature might be made generally available the Committee has prepared, at the request of the National Safety Council, a digest of the main hazards described in this publication, in the form of a popular talk which may be given by any safety director with or without lantern-slide illustrations.

Through these various channels, and through direct contact with industrial concerns, the National Committee for the Prevention of Blindness is seeking to do its part in the movement for

industrial safety. Its work is of an entirely philanthropic nature, and it welcomes as members all persons wishing to promote the public welfare, and who are desirous of contributing to the sum of human happiness.

Universal Danger or Caution Emblem. (Red ball in black design.) Adopted by the National Safety Council after many months of experiment with various suggested colors and forms.